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# THE WILDERNESS OF WORLDS

*A POPULAR SKETCH*

—OF—

## THE EVOLUTION OF MATTER

FROM NEBULA TO MAN AND RETURN.

*THE LIFE-ORBIT OF A STAR,*

BY

GEORGE W. MOREHOUSE.

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# PREFACE.

TRUTH courts light; but error shuns and deprecates impartial inquiry. The more difficult and important the question, the broader, freer, and more careful and thorough should be our study. The honest seeker after the truth gives all sides a hearing, and welcomes every addition to his mental equipment.

It cannot be denied that unbiased, intelligent judgment is extremely difficult of attainment. Our hereditary tendencies and early impressions are strong.

For forty years I have studied the subjects considered in this volume, and am to-day more than ever convinced that the legitimate domain of scientific investigation is as broad as the Universe,—and covers every thing that can be known.

I have in my mind a wilderness of trees. Those near me are of gigantic size; in the distance they seem smaller and smaller, fading gradually until the utmost limit of vision is reached. Not a single clearing is to be seen. The ground is covered with seeds, many of which are beginning to sprout. There are innumerable seedlings and young trees, and mature trees; all stages, the dying, the dead, and the prostrate, mouldering trunks,—a fair, a wonderful, but natural scene.



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I raise my eyes and look outward into space. I see the wilderness of worlds. The one on which I stand seems of immense size. The innumerable multitude beyond fade in the distance. I run to the telescope ; my vision is extended a thousand fold ; millions more come into view, and in the thousand times more distant circle of vision fade gradually until in the outer limits only glimpses can be caught of faint points of light.

The worlds, too, are of all ages like the trees, and the great deep of space is strewn with their dust, and is pulsating with the potency of new births.

How grand, complete and sublime are the works and workings of nature. We stand with bowed heads, entranced and speechless in the presence of the Universe. Held in its all-embracing arms, we are of it,—one and inseparable.

G. W. MOREHOUSE.

*Muskegon, Mich., 1898.*

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## *TRUE FREEDOM.*

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*"Is true Freedom but to break*
*Fetters for our own dear sake,*
*And, with leathern hearts, forget*
*That we owe mankind a debt?*
*No! true freedom is to share*
*All the chains our brothers wear,*
*And, with heart and hand, to be*
*Earnest to make others free!*

*They are slaves who fear to speak*
*For the fallen and the weak;*
*They are slaves who will not choose*
*Hatred, scoffing, and abuse,*
*Rather than in silence shrink*
*From the truth they needs must think;*
*They are slaves who dare not be*
*In the right with two or three."*

*—James Russell Lowell.*

[redacted]

# THE WILDERNESS OF WORLDS.

## *CHAPTER I.*

## SPACE.

IF we would acquire a correct knowledge of any object it must be examined from more than one point of view. Close observation is required to study its structure, and a distant, general view to judge of its relative value. This principle holds good in the thorough investigation of any thing or any subject.

Watch the baby when he first begins to look around. He is a true scientist. He investigates and thinks at the same time, and his way is our way. He begins with no idea of distance, size, shape, or color. He does not know whether an object is within reach, or a rod, or a mile away. All must be learned. He patiently watches objects, especially those that move or are bright. If he can reach anything that attracts his attention, it is tested by touch and taste, and later by smell and sound. We are all growing and grown up children. If it is the truth we are seeking, their methods must remain through life our methods.

As with the individual, so with the human race, knowledge of the magnitude of space begins at zero and constantly widens during intellectual growth. The distance of objects in the room, the space in immediate reach, once learned cease to awe. Familiarity banishes

fear. As development goes on the circle of the known becomes larger, and the awful unknown beyond correspondingly less in extent and influence. As the dread of the unknown weighs less and less heavily upon us, the known becomes more enjoyable. This is substantially true from start to finish in the race of life. At first we are helpless, relying upon the protecting care of others in ways we do not understand. Our first efforts to help ourselves are blunderingly made and we come to grief. As we learn by experience we become more self-reliant and begin to lose our fear. We are long in learning to walk erect. So in the dim past, the human race has struggled almost hopelessly to get upon its feet. However, the horizon is widening.

There are always some men, who, actuated by the love of truth for its own sake, are forever prospecting along the borders of the unknown. The opinion of one such pioneer, as to the extent of space, should count for more than the notions of an army of men whose knowledge and experience is confined to their own township, county, state, or planet. On such a subject men would not be expected to go to school to ants, whose travels have extended over only a few square rods, and whose powers of vision and intellect are correspondingly limited.

Little value would attach to the belief of an animalcule to whom a pint of water is a world. Neither should the seeker for truth tie himself to the dead and comparatively ignorant past. The space required to contain the Universe is immeasurably beyond the grasp of the primitive or infant mind.

It would be a most egotistical and presumptuous toad, that, on jumping against a tight fence would assume that space in that direction ended there, and beyond the fence there could be absolutely nothing. Yet, such a concep-

tion would be nearly at par with the idea of space entertained by men who could believe the earth to be flat and resting on foundations. Embarrassing questions arose as to what lay beyond the edge, or beneath the foundations.

While men believed that the earth was the fixed center around which sun, moon and stars revolved, and the amazing distance of the stars was as yet unsuspected; space in the cosmical sense, could be conceived of as having a boundary. The distance away might not be so very remote. Everything was very dark to the human toad. He was intellectually caged.

The discovery by Copernicus that the Earth and the other planets revolved around the Sun, a body much larger than the Earth, and located at a vast distance therefrom, dissolved into nothingness the foundations, firmaments, crystal spheres, and all the metes and bounds of creation and space that had been so learnedly and laboriously dreamed out by the ancients.

The mathematical demonstrations of the distances of the celestial bodies, and the discovery and application of the telescope set the world thinking. Old beliefs had to be patched up and revised.

The space limits required indefinite extension to take in the new additions of Copernicus, Kepler, Galileo and Newton. The stars, already being mapped and catalogued, began to be measured and weighed. The way was opening for the study of their nature. Certainty was taking the place of child-like guesses. Elaborate philosophical theories fell before the newly discovered scientific facts. It is ever thus.

Ideas of the extent of the space in which we exist were rapidly enlarged. The eyes had before seen without understanding. They were now opened in a new sense. They were not only opened, but their visual powers were

greatly extended outward in every direction by the telescope. The new instrument gave distant vision,—a general panorama of the visible Universe. The invention of the compound microscope gave close vision. Space too small to be seen by the unaided eye, or too distant for its reach, was diligently searched. There began to be caught a glimmering of the overwhelming fact of the infinity of space.

The invention and perfecting of the achromatic refracting telescope followed, with the construction of large reflectors, with great light-collecting and space-penetrating powers. The bounds of the visible Universe were extended many-fold. Still no limit was reached. With our latest telescopes, with greatly increased light-collecting power, the same story is told. The old boundary has disappeared, and forever. The philosopher who reasons that if an imaginary limit to space in any direction is asserted, it may legitimately be asked, what lies beyond? has been justified by the results of the growth of astronomical science. However remote the limit may be fixed the question still applies. So to the philosopher and astronomer alike, space is without limit. The opposite proposition is evidently not rationally thinkable, any more than the boundary line-fence of the Universe is optically visible.

Words fail to convey to our minds an adequate idea of even the imperfect comprehension we may reach of the extent of infinite space. We use the words infinite, boundless, limitless, but to have them mean much to us it requires a strong mental effort, a long and wearisome journey on the swift wings of thought, straight outward into the immense known, and still onward into the vast realms of the unknown, Universe. Let us think!

## *CHAPTER II.*

## TIME.

THE next questions that naturally arise are: Did space have a beginning, and will it ever end?

The duration of time required for ordinary events is easily measured, using the rotation of our Earth on its axis, and its period of revolution around the Sun, for our units of measure. For smaller values we divide days into hours, hours into minutes, minutes into seconds, and in fractions of a second we may go down as far as the mind can conceive. A fraction of duration so infinitesimal as to be unnoticed by us would seem long to an insect whose life-history begins and ends the same day. A year would seem to it an incomprehensibly long period,—365 times its own average of life. For the man of seventy, this would be equivalent to 25,550 years. To what comprehension of the duration of human life could such a tiny, short lived creature, however intelligent, attain?

Every estimate of duration, as of other matters, is relative. To the child looking anticipatingly forward to manhood the years drag slowly along. The aged remember their life as a brief struggle,—a "fitful fever."

The historical period looks long to us when considering it only in the light of the multitude of notable events that have occurred. When we compare the figures it shrinks to a span. The ancient Hebrew books take us

back less than 6,000 years, the Chinese not much if any farther, and the Egyptians and other early traditions, ruins and tablets perhaps twice that time. All guide us along a very narrow and slippery trail.

The pre-historic age was much longer, as science has abundantly demonstrated. It was many thousands of years before man had become sufficiently advanced to perpetuate his achievements by picture inscription or writing. Knowledge which was gained by the individual could only be communicated orally, and handed down a few generations by tradition, became lost to the race.

Much that was written in the earlier records is of uncertain value because of the writers not having been themselves witnesses of the events they described. They quite generally had to depend upon tradition, or hearsay. Tradition was hearsay upon hearsay, and therefore the poorest of evidence.

It happens, then, that we possess no authentic written record of perhaps more than one-fiftieth of the time since mankind have inhabited the Earth. Geology, as will be mentioned in another chapter, brings to our knowledge a natural record, proving the Earth to be hundreds of millions of years old.

We have learned from astronomy considerable about the times before the Earth was inhabited, and even before it existed as a separate body.

If in this way we can get glimpses backward, say, 1,000,000,000 years, still the question as to what there was before is as pertinent as it would be were the time covered only a week. When seeking for the bounds of space we were lost in infinity ; so in like manner, we fail to find a beginning to time.

It is possible to judge something of the future fate of our race and our planet, for we can see and study, with

telescope and spectroscope, worlds more aged than ours, and therefore nearer the termination of world-life. This vision, fully as worthy of credit as any evidence relating to the past, carries us forward many millions of years in our estimate of future duration.

Go forward in imagination as far as this vast interval takes us, and from he new stand point take another look, and so on and on forever.

Space is infinite, and time is eternal. There could have been no beginning, and there can never be an end. To-day is as much a day of beginning, or of ending, as any other day that may be selected in the past or future.

Let us think about time, as we do about space, and study both together. There is an abundance of room and time for an exceedingly active Universe.

## *CHAPTER III.*

## MATTER.

BY the word matter we designate the substance that constitutes the world-building material of the Universe. It is evident to our senses, exists all about us, and in our own bodies. All are more or less familiar with its properties, and its wonderful combinations and varieties. Its usefulness and beauty are recognized and admired in the mineral, the vegetable, and the animal kingdoms. Volumes, yea, whole libraries would be inadequate to do justice to the grand subject. Anything like a systematic discussion of the well known properties and conditions of matter would not come within the scope of this volume. I can only indicate a few facts and conclusions with which we are at present most concerned.

Matter exists in at least three forms,—solid, liquid, and gaseous. Its solid form is due to the absence of heat, and on the application of heat it becomes liquid. A still higher temperature vaporizes. It then fills more space, but on cooling it resumes its original form and size.

Chemical action also changes the forms of matter, decomposing combinations and forming new ones, liberating the component gases of substances, and dissolving minerals or other solids or restoring them. The solid substance becomes an invisible gas, or the reverse. Colorless solutions when combined may produce beautifully

colored precipitates. It would be impossible to give much more than a hint of the varieties found in Nature.

Notwithstanding all the changes of form, and the many complex chemical combinations that matter has undergone in Nature, in the laboratory of the chemist, and in the seemingly destructive heat of the furnace, or of the Sun, not one particle has ever been destroyed. However changed it may have been, every ounce, and every grain and fraction of a grain, may be accounted for.

It has come to pass that the doctrine of the indestructibility of matter is established beyond a doubt. Matter may be divided and subdivided, and separated into microscopic particles and these into smaller molecules, and those again into indivisible atoms, thousands of times more minute than the molecules, yet, not one of the atoms can be destroyed. It takes its place again, and performs its part in the shifting scene of the Universe, in accordance with the economy of Nature.

Matter, then, being indestructible, its creation out of nothing becomes most emphatically unthinkable, and as a matter of course unbelievable. It has always existed and always will. Like time and space it is without beginning or end.

In olden times, along towards the infancy, or perhaps very early manhood of the race, when the germs of knowledge had not as yet begun to sprout, strange things were believed. One might harbor the notion that the strength of the belief was proportional to the unnaturalness of the then prevailing theories. Matter, all creation as known and believed in, was limited to small portions of south-western Asia, southern Europe, north-eastern Africa, a few islands, the surrounding ocean, the Black, Caspian, Mediterranean and Red seas, the clouds, the Sun, the Moon, and the stars "also." The wind was a

supernatural mystery. The Sun was a very small body, which like the Moon and stars, was made to give light for the Earth, and at night it withdrew behind the great northern mountains, to re-appear in the morning and continue its useful course. What little there was of the Earth was flat, or nearly so, rested on foundations, and was surrounded on all sides by an ocean, a border of mountains, and beyond them the jump-off. The sky, firmament, or heaven, made of crystal, and supporting the Sun, Moon, stars, gods and angels, rested securely on the surrounding mountains. Will any student of ancient history call this an exaggeration?

The art of printing with movable types was discovered as late as A. D. 1438. The first practical working steam engine was made in 1774, and steam navigation began with the present century. This century has also witnessed the invention of railroads, and the harnessing of electricity. The new astronomy, chemistry, geology, biology, etc., have been born, or which is much the same thing, had a new birth, since the discovery of America in 1492. If, then, such a large percentage of the most important advances in knowledge have been made so recently, we shall be warranted in giving little weight to ancient authorities. The respect due to age, or antiquity, should fall short of leading the immeasurably more competent living observer to wink at error, or to permit his judgment to be swerved in the least from the truth.

The modern observer, with new and improved instruments and methods, has perhaps reached his higher results, thus far, in the study of the nature and properties of matter, rather than in enlarging knowledge of its extent. This study necessarily embraces careful investigation of the manifestations of force that are always present.

Changes are everywhere taking place. The forces producing, accompanying, and resulting from these changes are found to be constant quantities. There is always an exact relation between the force exerted and the results attained. No power is ever gained or lost. It is found that energy, like matter, is incapable of being either created or destroyed.

As far as the telescope can penetrate space, matter exists. Every improvement in the instrument enables us to see clearer the stars already discovered, and brings to the eye faint glimpses of swarms still farther removed.

It is probable that the portion of the Universe, now visible from this planet, is less to what lies beyond our sight than is a grain of sand to the whole solar system.

We begin to realize the extent of matter. It, with its varying forms of energy, exists everywhere throughout boundless space,—"yesterday, to-day and forever." In extent and duration, that which is true of space and time, is also true of world-material and its inherent energy.

Examine a finely pulverized substance, for instance indigo, in a film of water, with a powerful microscope, and all the freely suspended particles are in constant motion. This is called the Brownian movement, for its discoverer, and it is also called molecular motion.

Matter, whether comminuted or in great masses, acts and is acted upon. Even the apparently solid and inert rock is permeated by unseen force. Remove the force that results in what we name—attraction of cohesion, and the rock would crumble into dust. Its integrity is maintained for a time against the assaults of the elements, because it is not devoid of sustaining forces. This is as true, if not as evident, as the display of magnetic power by the loadstone.

Inertia of matter is a term only to be properly used in the restricted, mechanical sense. Receptivity and activity are present in every particle of the material of the Universe.

Can matter thus active be properly called dead? Let us revise our inherited and crude notions, and fearlessly acknowledge that such an anomaly as dead matter does not exist. The moment the vital forces cease to act in the living organism, decomposition into the original elements begins. This is chemical action. It is not a cessation, but a change of activity.

Perhaps, then, it might be better to call it living matter, even if it be necessary to add to the elasticity of the word *living*, to make it fit the idea.

## *CHAPTER IV.*

## DISTRIBUTION OF MATTER.

THE distribution of matter in space is by no means uniform. That fact might be suspected from the different apparent magnitudes of the stars. This appearance being found not to be entirely due to differences in distances, or in intensity of light, the suspicion becomes a certainty. In our planetary system no two bodies are of the same size. Looking out upon the stars we see them grouped irregularly. Some portions of the heavens are exceedingly rich in stars, while others are very poor. This is also the case with telescopic stars.

There is want of uniformity everywhere. This is as true of the stars in the heavens as of the trees in a forest, or the stones in a field. This fact is eminently characteristic of the works of nature. The celestial bodies are as diverse in density as they are irregular in distribution.

They are scattered as lavishly and wastefully as are pollen grains, or the grains of sand on the shores of the ocean. Nature, with infinite resources, can well afford to be prodigal, even of worlds.

If the word prodigality may be used in regard to the number of the stars, what can be said of the immensity of the surrounding space. This space is also occupied. It is probably filled throughout with an exceedingly rare me-

dium. Aside from planets, it is known to contain innumerable bodies smaller than the stars, and revolving around them. Such bodies fall upon the earth continually in the form of meteoric stones and meteoric dust.

Notwithstanding the irregularity of the distribution of cosmical matter, there is no evidence of its not being everywhere in great profusion. In regions of space that appear comparatively empty there may be the average quantity of matter. It may be present in numerous bodies too small to be seen, or in larger dark ones. We have very good reasons to suspect the presence of dark bodies of no inconsiderable size in the starry realms. I shall doubtless have occasion later in this work to refer to them more at length.

The masses of matter that we call fixed stars are distributed at great distances from us and from each other. Relatively few can be said to be comparatively close. Most of them are sparse compared with the space occupied. The fact that these distances are indeed enormous is capable of accurate and unquestioned proof.

A surveyor, wishing to measure the distance across a stream, can do so without crossing if he has an instrument adapted to the purpose. He measures a base line along the bank, and takes observations from each end of the line, of some object across the stream, measuring the angles. He then has a triangle with a known base line and two known angles, the other lines meeting at the apex across the stream. The calculation of the distance, from the data thus obtained, is a simple problem in plain trigonometry, and the width of the stream is accurately determined.

In like manner, observations of the Sun, Moon, or planets may be made, and angles measured from two distant positions on the Earth, giving a known base line.

Then, if the measurement be exact, the distance can be computed.

The different positions on the Sun's disk of the planet Venus, when in transit, as viewed at the same instant from points widely separated, gives the ground for a good method of computing the distance of the Sun.

Observations may be taken on a fixed star, six months apart, using in this case the whole diameter of the Earth's orbit for a base line, when, if the star shows a measurable parallax, its distance may be determined.

So it is seen that the distances of the celestial objects are ascertained with mathematical accuracy, subject only to errors of measurement of parallax. Their distances being approximately known, a correct idea can be got of the actual sizes of those near enough to have measurable disks, and a valuable rough guess on many others.

It is very evident that if all the matter contained in the region within our range of vision was distributed uniformly, there being no stars or other condensed bodies, this homogeneous substance would be exceedingly rare. Doubtless it would be more attenuated than the lightest known gases. This primary matter, if at rest, would be invisible. In this homogeneous, inert state, universal energy might be imagined as lying dormant, awaiting some outside creative impulse. This impulse once given, the known laws governing the attraction and condensation of matter, would in the course of time transform portions of the invisible material into tangible worlds.

If such a condition of uniformity, and absolute rest, ever obtained, which is more than doubtful, it long since came to an end. Now, there are no known exceptions to the universal rule,—of motion, variety and change. The distribution of matter in space could scarcely be imagin-

ed to be more diversified. Any seeming sameness is dispelled by closer and more careful scrutiny.

The spectroscope has given the study of the character and distribution of matter a new impulse. Elements familiar to us as constituents of our earth are found to be present in the celestial bodies. In the most remote starry regions, not only are the elements found, but their conditions are determined. The instrument enables us to judge in a general way of their temperature. It may not be out of place to briefly explain the construction and working principles of this wonderful instrument, to further prove upon what solid foundations the new science rests.

A glass prism refracts and disperses light. The colored image produced is called a spectrum. The prism separates the colors because each color has a different wave length. The length of wave is the measure of energy. The spectrum divides into the seven primary colors, red, orange, yellow, green, blue, indigo and violet,—always arranged in the same order. Besides the colored light waves that are thus visible, there are many more beyond the red at one end of the spectrum, and the violet at the other. The length of this invisible spectrum greatly exceeds that of the visible. These rays to which the retina remains insensible are analogous to those that are visible, and produce powerful chemical and thermal effects. They indicate the heat energy and chemical nature of the Sun or other luminous bodies from which they emanate.

In the spectroscope several prisms are generally added to increase the dispersion, or diffraction-grating may be used instead of prisms to produce the desired effect. To cut off diffused light, and make the image more distinct, the light to be examined is admitted through a narrow slit. A lens behind the slit renders the rays parallel as

they enter the prisms. A small telescope is added to better view the image, and a micrometer to measure. Some instruments are so made as to admit of the direct comparison of the spectra of two objects. Thus the spectrum of the Sun, or of a star, may be directly compared with that of a known substance heated to incandescence. There are spectroscopes specially constructed for special purposes of analysis.

The spectrum of the Sun, for instance, is crossed at right angles with its length by innumerable lines. The same substance, when in the same state, always gives the same bands and lines,—peculiar to itself, and in the same places in the spectrum. It follows that spectrum-analysis of the rays from luminous bodies throws light on their chemical constitution and physical condition.

Thousands of the dark lines of the solar spectrum have been mapped, that is their places in the spectrum are recorded. The presence in the Sun, of hydrogen, sodium, iron, magnesium, copper, zinc, calcium, nickel, etc., is established beyond all question.

Not only can the presence of a certain element in sun or star be demonstrated, but also the physical state in which it may be found, whether as a solid, or a liquid, or as a gas.

As the position of any given ray in the spectrum depends upon its length of wave, it is evident that if the luminous body is approaching rapidly the rate will be increased. This principle is applied to determine whether a star is approaching or receding. In this way the rate and direction of motion of certain stars have been ascertained.

Spectrum-analysis applies to compounds, as well as to the substances now known as simple elements. When the temperature is increased sufficiently the characteristic

spectrum of a compound changes into the lines peculiar to its constituent elements. It is found that when submitted to still higher degrees of heat the spectra of the so-called elements show a tendency to break up in the same manner. Are they also compound? Is there more than one primary element?

Solid, or liquid, bodies give out continuous spectra. Gas gives out bright lines only. When light from solids or liquids passes through a gas, the gas absorbs those rays of which its own spectrum consists.

It may be considered proven, that we have to deal in the stellar regions with the same elements we are in close contact with in the Earth, and that the distribution of these substances is co-extensive with that portion of space that is known. Lockyer aptly calls the lines of the spectrum, "The cypher of the Universe."

## *CHAPTER V.*

## FORCE AND MOTION.

WHEN we speak of a law of nature, we do not mean a decree or order given by a superior authority, but simply the orderly, uniform course of nature; any certain set of conditions always being followed by the same phenomena. The law of gravitation, is recognized by that quality of matter that causes the mutual attraction of bodies. The three laws of motion as laid down by Sir Isaac Newton, are examples of natural "law:" (1) If a body be started in motion, and if no force acts upon it, it will continue to move in the same direction and with the same velocity. (2) Change of motion is proportional to the acting force, and takes place in the direction of the straight line in which the force acts. (3) To every action there is always an equal and contrary reaction. The laws of Kepler might be mentioned: (1) The orbit of each planet is an ellipse, the center of the Sun being in one of the foci. (2) The radius-vector, or line drawn from any planet to the Sun describes equal areas in equal times. (3) The squares of the times of the planets revolutions are as the cubes of their mean distances from the Sun.

The important discovery by Newton of the law of gravitation, and that it applied to the heavenly bodies, that they attract each other directly as their respective masses and inversely as the square of their distances, is merely the recognition of existing principles and facts. It is not explained why masses of matter attract each other.

It has been suspected that gravitation is a result of the activity of matter, and acts in proportion to that activity. Along this line we have a new theory of gravitation, by Singer and Berens, that: "Two bodies in different states of excitation and free to move, will move toward each other, the intensity of attraction being proportional to the difference in excitation." (*Popular Science Monthly, Oct., 1897.*) Bodies in the same state of equilibrium would then have no attraction of gravitation. Few, if any, such bodies can be found. There can be little doubt that this is the direction in which research may reasonably be expected to eventually lead to satisfactory results.

When a body is at rest it will remain so until force is applied; and when once set in motion it takes a resisting force to stop it. This law applies relatively, as in the case of terrestrial objects; but in the broader application there is no such thing as a state of absolute rest. The solid rock is gradually being reduced by the elements,—and is swept along with the earth and the sun through space. There is motion everywhere.

Where a body strikes another, its motion is arrested; the force causing the motion is not lost, but is converted into heat—another form of force. The heat force thus developed is the exact measure of the force causing the motion. This is the case whether the moving bodies are atoms or stars,—moving slowly or rapidly. The principle is therefore universal that force is conserv-

ed and cannot be destroyed. Its conversion into other forms shows that the different forms of force are correlated.

If heat is employed, with engines or otherwise, to lift a great weight, the weight in coming down, with whatever velocity, will give out exactly the same amount of heat. It has been calculated that the force developed by the contraction of three hundred feet a year in its diameter would supply all the heat the Sun sends out. The working energy of a steam engine exactly equals the force represented by the heat of the steam.

The amount of force, like the amount of matter in the Universe, can neither be increased nor diminished. It can be changed from one form into another, heat into electricity, electricity into heat, or either into motion and the reverse, and so on indefinitely.

The doctrine of the correlation of force recognizes the fact that all the different kinds of force in the Universe are connected together, being manifestations, under different conditions, of the active properties of matter. It implies the unity of matter and force. Such a thing as matter without force, or force without matter, is unknown.

If the attraction of the Sun should cease, the planets would leave their orbits, in a tangent, and continue on in a straight line into space until stopped by collision with other bodies, or by a resisting medium. If after the original impulse was received from the rotating nebulous mass from which the planets were formed, the tendency to continue on in the same direction were removed, the attraction of the Sun, acting alone, would cause the planets to fall to that luminary. The two forces, contrifugal and contripetal, continuing as they must in the nature of things to act together, the planets move in their orbits balanced midway between the two. If many forces are acting together the result is correspondingly complex.

No force, of whatever kind, ever proceeds from nothing, and without cause, but it always has its origin and cause in some preceding form of energy. It is therefore clear that motion is universal and eternal like matter and force.

Some of the most important operations in nature are carried on by the motion resulting from the attraction and repulsion of molecules. That the little bodies have polarity, like larger masses, which influences their motions, will not be questioned. Molecular attraction acting at infinitely small distances, is the cause of cohesion. The action of the molecular forces keeps the molecules together in mass, although they do not actually touch each other. The ceaseless clash of atoms and molecules pervades alike organic and inorganic matter. Their motion is the complex result of the ever active internal and external forces; their constant action and interaction. Their motion is converted into heat, electricity, etc., which are also forms of motion, and have their mechanical equivalents.

The chemical separation of atoms develops energy that is transmutable into heat, or other forms of force. Animal heat and vital force represent the energy of the food consumed, and that in its turn is mostly derived from the energy of the Sun. Solar energy is stored in wood, coal, food, water elevated above the sea level, and in water and air in motion.

As the Sun and Earth are radiating heat into cold space, it follows that the time will come when their energy will be dissipated, and the life of the solar system will come to an end,—a matter of less importance to the Universe than is the death of a limb of a tree to an extensive forest. Other systems and other limbs have for this reason a greater supply of fuel and food.

Vital forces being correlated with chemical and other physical forces, and like them, being properties inseparable from matter, and therefore as here manifested constituents of the solar system, must share its fate.

The evolution of the living parts of the Universe is accomplished through the supply of nourishment derived from the so-called dead, or decomposing portions. In all this changing process, there can be no atom of matter, or its inherent force and potency, either lost or gained. To every excitation of energy above the average level, there is a corresponding depression elsewhere, and the ebb and flow is universal and eternal.

## *CHAPTER VI.*

## NEBULÆ.

DOUBTLESS the reader has noticed that the preceding chapters are of a somewhat preparatory or introductory character. An attempt has been made to clear the way for a broader conception of the real nature of the celestial bodies, before proceeding to anything like systematic description. We are trying to get better acquainted with the matters with which we have to deal.

I purpose to take up, first the nebulæ, then the stars, solar system, etc., in the order of their evolution. It was thought to be the best and most natural way of treating this great subject to begin with the primitive or commencing stage of world-life. This plan is also in accordance with the general scope of this work, it being an attempt to aid in arousing popular interest regarding the more advanced teaching of Science. To better do this I begin with the more simple forms of matter and go forward to the more diversified and complex.

The plan necessarily includes a brief review of the evolution from primitive matter upward, and the return to the same state. It must not fail to call attention to the eternal continuity of such cosmical changes.

The ancients knew nothing of the nebulæ. They are not even mentioned in their most elaborate and popular theories of creation. The stars were mentioned among

the "alsos," but the nebulæ, never. Yet, careful investigation has proved them to be the grandest and most important masses within our knowledge. Our earth, the solar system, the starry heavens visible to the eye, sink into insignificance when compared with them. We have in mind the immensity of their extent and the promise of their future.

When looking for nebulæ, the Moon must be absent and the air clear and steady. When astronomical objects are seen near the horizon, we look at them through about 4,000 miles more of dust-laden air than we do when they approach the zenith. Therefore, as a nebula is a dim object at the best, look for it only when it has reached a favorable altitude.

At least two of them in our northern sky may be seen dimly, with the naked eye. These we will first mention. Exceptionally good eyes may detect a few others. There are some 5,000 visible with telescopes, and the list increases with the improvements of the instruments. The use of photography in a systematic manner will probably add thousands to the catalogue. There are a few dense clusters of stars that might with the naked eye be mistaken for nebulæ.

In the splendid constellation of Orion, below the lowest of the three stars in a straight line called "the belt," lies the great nebula of Orion, readily visible to the naked eye. It looks like a dim hazy light, and may easily be mistaken for a tailless comet. With a telescope having only a two or three inch object-glass and a low power eye-piece it is a most wonderful object. It is irregular and branching, and more luminous in some portions than in others. The margins fade away in the distance. A most interesting multiple star, known as Theta Orionis, in the dense part of the nebula, is by such a small telescope,

resolved into four distinct bodies. In large instruments two of them are seen to have smaller companions. This object is sometimes called the trapezium of Orion from the figure formed by the four principal stars. At one time Lord Rosse, with his great reflecting telescope, thought he had succeeded in resolving the part of the nebula about the trapezium into stars. Fifteen years later he seemed inclined to attach little weight to the observation. The spectrum-analysis of Huggins showed the presence of gases, including hydrogen. The later work of Lockyer, and others, has added iron and magnesium.

Bright lines of other metallic vapors and of hydrogen, being generally absent in the spectra of the nebulæ, Lockyer concludes that "The temperature and electrical excitation of these bodies is at a minimum."

One of the grandest in the heavens, so plain to the naked eye that it is often mistaken for a comet, is the great nebula in the belt of Andromeda. To find it, start if you please from the Pole Star, in the opposite direction from Ursa Major, or the Great Dipper, and at about the same distance from the pole, stop to admire the bright constellation, Cassiopeia. Its principal stars form a figure that somewhat resembles an inverted chair, or an irregular W, with its opening toward the Pole Star. Still farther from the pole, twice as far, you observe four stars forming a great square,—Pegasus, or the flying horse. The star in that corner of the square nearest Cassiopeia is in the head of Andromeda. Now, a line drawn from the farther star diagonally through the square and extended will point to the belt. It is curved, and consists of a bright star and two dim ones. Near the outer small star is the great nebula. Passing on in the same direction to the vicinity of Cassiopeia will bring you to Perseus, a constellation containing many rich fields. One of the

finest clusters in the heavens is located here. To the eye it looks hazy like a nebula. The great nebula is about midway between Perseus and Pegasus.

The Andromeda nebula is long and oval, and brightens toward the center. It has not been resolved into stars by the best telescopes, although with small instruments it is still a very interesting object. Huggins found its spectrum to indicate that it is not gaseous.

The best long-exposure photographs show it as elliptical, with broken spirals almost ring-like, and faint irregular nebulous extensions to immense distances. Some of the spirals are much more dense in some places than in others and seem to be gathering in masses. Very little if any stretch of imagination is required for one to entertain the belief that in this nebula we behold the spectacle of the birth of stars.

This instructive feature of the spiral nebulæ, viz., the tendency of the ring-like spirals to break up into secondary masses evidently revolving around the central mass, is still more clearly shown in the nebula in Canis Venatica. In this famous object the feature in question is too pronounced to admit of doubt. In small telescopes it is seen as a misty spot, about three degrees, (the length of the belt of Orion,) south from and preceding Alkaid, the end star in the tail of the Great Bear, or handle of the dipper. Any direction from the North pole of the heavens is South, yet, the best time to trace and identify constellations, is when they are on the meridian.

North-west of the square of Pegasus we come to Cygnus, a constellation extremely rich in telescopic stars. It lies along the Milky Way, the principal stars forming the figure of a cross, with the brightest star in the top of the upright piece. Directly west of Cygnus is a very brilliant white star, Vega, in the constellation Lyra. Two

small stars about two degrees apart, on the east of Vega form with it a triangle with the great star at the apex. Half-way from Vega to the star in the foot of the cross in Cygnus you pass two stars about two degrees apart, Beta and Gamma, in Lyra. The only annular nebula accessible by common telescopes lies between these two stars. This wonderful object is probably in shape a perfect ring. It lies inclined sufficiently to appear to us slightly oval. A light nebulosity is seen in the interior of the ring, but no central body.

It is well to remember our bearings, doing the best we can toward "blazing" our way, for we will want to return to this captivating region.

While we are so near, take a look at Hercules, the constellation next west of Lyra. You will recognize it by a trapezoid of stars of the third magnitude. They are on a line with Vega and the star of the second magnitude in the cross in Cygnus. Between the two stars forming the west side of the trapezoid is a superb object, just visible to the unaided eye, and seeming to be a nebula when viewed with low powers. It is, in fact, a splendid globular cluster of stars. This is one of the most interesting objects in the heavens. It is no exaggeration to say that in this comparatively dense cluster there are thousands of stars,—a galaxy in itself. Compare it with the easy cluster previously mentioned, in Perseus.

When Lyra is in the zenith turn your back on the northern sky and stroll to the southward. The red, first-class star Antares, is in the constellation Scorpio, the most conspicuous in that region. Half-way between Antares and Beta Scorpio, the second-magnitude star north-west of it, is another fine object. Dwell long in Sagittarius, next east. See that beautiful cluster near the handle of the "little dipper," and sweep around and

along up the Milky Way. Much time may be profitably spent at almost any point along the Galaxy.

Find Beta Aquarius by drawing a straight line from the north-east star in the square of Pegasus through the south-west star. Continue on about the same distance and reach Alpha Aquarius, a star of the third magnitude, and then half as far and come to Beta, same magnitude. About six degrees north of Beta is a fine nebula, and about the same distance south-west is one of the finest of a class of nebulæ called planetary, from their resemblance to the disks planets show in the telescope.

The "dumb-bell" nebula is located in Vulpecula, and may be found by extending a line drawn from the ring nebula in Lyra through Beta Cygni, the star in the foot of the cross, about the same distance farther, and thence some three degrees north. This remarkable object has been the center of much study and speculation.

Near Merak, the pointer farthest from the pole, in the Great Bear, is a large, pale, planetary nebula.

Nebula No. 3249 of the general catalogue, in Coma Berenices, as photographed by Roberts, shows nucleous to be a nebulous star of the 12th magnitude. Surrounding the nucleous at a great distance is a "well-defined ring, and in the ring several star-like condensations of nebulosity are involved." Outside this ring is another fainter one, and beyond is a third still fainter.

Materials for profitable investigation are present in profusion on every hand. We are conscious of marked moral and intellectual expansion as we stand uncovered in the presence of the Universe. The ego is lost and absorbed.

Herschel was the first to discover extensive, faint, irregular nebulosities. Patches of this diffused nebulous matter are numerous. They are sometimes comparable to constellations in the number of square degrees covered.

Sometimes the diffused matter is associated with the denser nebulæ, or with stars, or it may be found in detached masses.

These nebulous clouds, among and beyond the visible stars, reveal one of the first steps in the concentration and evolution of matter. As indicated by the spectroscope they consist of finely comminuted particles, substantially the same as meteoritic dust. The processes of disintegration have performed their work. The old material has resumed its original form, its elementary state, and is once more ready for rebuilding.

The atoms and molecules are constantly moving like the particles of powdered indigo referred to. They no sooner separate than they begin to recombine. They collide with each other and the impact produces heat, and the forces are aroused into action that assists re-aggregation. Streams of meteorites, sooner or later, come in collision. The collisions develop heat and light. As new masses increase in size and power, larger particles are attracted—and from greater distances. So new condensations and combinations inevitably result from the collisions of atoms, molecules, two or more small or large bodies, or streams of meteorites.

It is not to be presumed that amid the activities of the larger stellar masses any of the small particles, or any molecules, wherever situated, are ever at rest. Even the larger planets are perturbed by the attraction of the Sun and the other planets. A notable example was the discovery of the planet Neptune by taking advantage of the measurable disturbance of the motions of Uranus caused by the attraction of the unknown planet.

Comets and meteorites are captives to the larger bodies around. Each particle or planet, and each fragment or molecule acts upon others and they upon it. When their

forces are active they attract, cohere and build up, and when their heat becomes lost by radiation, and their powers dissipated, they fall to pieces. The resulting dust comes within the attraction of nebulæ, suns, or planets, and falls to them, or, escaping and eventually coming in collision with other dust becomes a factor in the formation of new worlds. Activity no sooner reaches its limit in one direction than it begins in another.

The weight of evidence favors the nebular hypothesis as supplemented and strengthened by the meteoritic hypothesis of Lockyer. If, then, the diffused nebulosity is the first step, we ought to be able to arrange the 5,000 known nebulæ in groups showing gradual evolution toward the formation of stars. That such is the case has been recognized by advanced astronomers since and including the elder Herschel.

It is a common thing for nebulæ to show irregular condensation,—thin in some places and dense in others. Some have a single nucleous, others two or more. So we have single, double, and multiple nebulæ. They are seen in all stages, from irregular, irregular rounded, round, round with central nucleous, up to globular. It would be a very small nebula that would go to make only one star. The greater ones contain the material and potency for numerous sun-systems. The telescopic results are confirmed by the spectroscope, that instrument proving the condensation and evolution of nebulæ. The two noble instruments agree, and the verdict accords with the orderly march of Nature. Neither is reason antagonized.

Photographs of the nebulæ also confirm this opinion. Details, undetected by the eye, have been brought out by long exposure of the sensitive plate, and photography is justifying the confidence and hope of Draper. The se-

crets it has revealed all lie along the line of natural evolution,—like those yielded by the Andromeda and Canis Venatica nebulæ.

There is variety amid the general sameness. There are marked differences in the modes of separation of secondary bodies from their primaries. As the conditions are never exactly the same, this was to have been expected. In some the central body is large and the secondary ones small, as in the solar system. Other nebulæ divide into two nearly equal parts. In the final globular condensation, accompanied by the loss of heat, processes and results are similar.

Differences in volume, in molecular activity, in the advent and direction of intakes of meteoritic streams, in the attraction of neighboring bodies and the tides caused thereby, lead to differences in the sizes, distances, etc., of the stars formed therefrom. The *natural* rules in this broad realm, as elsewhere.

All drawings of the nebulæ have proven most unsatisfactory, and successful photographs of them are of very recent date. Astronomers have therefore not been in position to record changes in any particular object. Most of the changes are so gradual that many centuries might be required to obtain data to warrant drawing a conclusion from observations on one object. However, this delay is by no means necessary.

We do not have to watch the growth of an oak tree for a century to know its history. When we enter a forest we see its mates in all stages of growth from the acorn to the mature specimen. It is as true of the nebulæ as of the forest. Taken in the aggregate the lesson is not to be mistaken. We have the complete connection from the diffused disintegrated material to the star that shows a spectrum like our own star-sun. There is no break.

Neither is there any dividing line between a nebula and a nebulous star, nor between a nebulous star and one like our sun. There is no region of the stars, and beyond a region of nebulæ. All forms exist together in space and time, and are intermixed, as we find all stages of the growth of trees in a forest present together. The continuity is complete.

This living picture represents the life-history of a nebula, from its birth amid the heat and force—developing collisions of its atoms and molecules up to the time when it may be called a star. During this long period there has been a great increase of heat and light. The constant clash of its particles within itself and with accessory streams has produced these effects.

The energy developed by the aggregated activities has far exceeded the losses through radiation. Whether in the form of heat, light, magnetism, gravitation, or other forces it has been effectually stored. Not, indeed, for a designed purpose for future use, but simply because energy, like matter, is indestructible. It cannot escape.

## *CHAPTER VII.*

## STARS AND STELLAR SYSTEMS.

WE are now to consider one of the most important links in the chain of evolution, viz.,—The stars that shine by their own light, commonly called fixed stars. All those visible to the naked eye are thus designated excepting five or six planets.

That branch of astronomy which has to do with the naming of constellations, groups, and the principal s tars and determining with more or less accuracy their position in the heavens, is of ancient date. A catalogue of stars was made two thousand years ago. The Greeks must be credited with the first accurate, really scientific knowledge of the stars.

Thales, 640 B. C., had made a fair beginning in this the oldest of the sciences, and much advance was made in the following eight centuries. But, alas for the hopes of the Greek and Roman sages, the foundations of their civilization were fast being undermined, and all further progress for the time checked. The world was given over to political dissensions, disastrous and devastating wars, and fruitless theological contentions, persecutions and vain imaginings. The period known in history as the Dark Ages followed, from which, thanks to Science, Europe has been for a few centuries emerging.

While the dense darkness of the Middle Ages brooded over Europe, the Arabs, then known as Saracens, culti-

vated the sciences of mathematics and astronomy, and saved to mankind part of the old knowledge, enriched by their own observations.

From all this it has come to pass that the names we find among the stars are, as it is proper they should be, Greek and Arabic. The principal stars are thus named, and the Greek alphabet is used in designating the stars of each constellation in the order of their apparent magnitudes. When the alphabet is exhausted the Arabic numerals are used.

In calling particular attention to some of the more brilliant constellations, and more interesting and instructive objects in the sidereal heavens, it is thought best to begin with the Great Bear, with which we are already somewhat acquainted. We need no introduction to the seven bright stars forming the figure of the Great Dipper. Mizar, the middle one of the handle, is a beautiful double-star. Alcor, very near Mizar, and visible to the naked eye, and a still smaller star, are seen with Mizar and companion in the same telescopic field with a low power, and make a fine group. An ordinary spyglass just separates the companion star from its principal. They doubtless form a binary system, with a long period of revolution.

The two outside stars in the bowl of the dipper, called the pointers, point to the Pole Star, in the constellation Ursa Minor, or the Lesser Bear. Polaris, the pole star, lies at the end of the handle of the little dipper, and is itself a double-star, easy for small telescopes.

The two stars constituting the bottom of the Great Dipper point toward the very brilliant star, Capella, in Auriga, or the Wagoner.

A line drawn from Mizar through Alkaid will point toward, and serve to identify Arcturus, a star of the first

magnitude, in Bootes ; and also Corona Borealis, or the Northern Crown, the stars of which form a circular figure or wreath. Arcturus, two other principal stars in Bootes, together with the star of the second magnitude in the Crown, form a large Y, with Arcturus at the bottom. Mirac, the one in the center of the Y, is a fine double,—probably a binary system. The components are beautiful in color, the larger one yellow and the smaller blue. This star is sometimes used as a test for small telescopes.

The sickle, with the large star, Regulus, in the handle, forming part of the constellation Leo, lies west of Arcturus and south of Ursa Major. South-west of Bootes is Virgo, with many interesting double-stars and nebulæ, and one star of the first magnitude.

East of Corona Borealis we return to Hercules, where are a number of fine objects,—then to Lyra. Vega has a minute companion, very close,—a test for a good telescope of about three inch aperture. Epsilon, the northern-most of the stars near Vega, forming the small triangle, is a grand double-double ; the lowest powers separate it into two, and moderate powers show each of these to be a fine binary system. There are several other very faint points in this most instructive group.

Beta Cygni, referred to in the preceding chapter, is one of the loveliest colored double-stars in the heavens, and fortunately within easy reach of small instruments. The larger constituent is of a golden yellow, and the companion a light blue. The colors are better seen by putting the pair a little out of focus.

Nine degrees north-east of Algol is Algenib, a bright star in Perseus, which with Almaack, in the foot of Andromeda makes a right-angle at Algol. The open side of the angle is toward Cassiopeia. The head of Andro-

meda is in the great square of Pegasus ; the belt near the great nebula, and at about the same distance toward Perseus you find Almaack, and readily distinguish the perfect right-angle, and Algol, the most celebrated of the variable stars.

Algol is a star of the second magnitude for about two days and thirteen hours, when it commences to decline in brightness, and in the course of nearly three and one-half hours reaches the fourth magnitude, where it remains for eighteen minutes, then begins to increase, and in the same time it took to decline, regains its brilliancy. Its period, accurately stated, is two days, twenty hours, forty-eight minutes and fifty-five seconds. Almaack is double with a moderate sized telescope and triple with large ones.

Rigel, the great star in the foot of Orion, is a double-star affording a fair test for small instruments, under favorable atmospheric conditions. The lower star in the belt of Orion is triple, and Betelguese, the bright star in the east shoulder, is variable.

The three stars in the belt of Orion point north-west to Aldebaran and the Pleiades, in Taurus, and south-east to the brightest star of all, Sirius, the dog star, in Canis Major. East of Betelguese is Procyon, a first magnitude star in Canis Minor. North of Procyon are the bright stars Castor and Pollux, in the heads of the Twins, or Gemini. East of Gemini lies Cancer with the interesting naked eye cluster, Præcepe.

Aldebaran and the Hyades make an imposing cluster as do the Pleiades. The latter when a low power eye-piece is used, affords rich fields. Aldebaran has a minute companion.

The finest double-star of all, in some respects, is Castor, the northerly one of the two principal stars in Gemini.

The components are of nearly the same magnitude and easily separated with a small telescope. In this pair, as in many others, a movement of revolution has been observed.

Antares, the great red star in the heart of Scorpio, is a double that will repay you for your time spent on it when conditions are favorable.

Here are the names and periods of revolution of a few double-stars: Kappa Pegasi 11.04 years; Delta Equulii 11.05; Beta Sagittari 18; Zeta Herculis 34; Eta Corona Borealis 42; Sirius 52; Alpha Centauri 81; Mu Bootes 219; Delta Cygni 377; Castor 1001; and Zeta Aquaris 1624 years.

Let the reader go ahead; he will find lovely objects for study in every constellation.

The number of stars visible to the unaided eye in the northern sky is estimated at 3,000, and in the whole heavens at 5,000. It is within reasonable limits to say that a moderate sized telescope will show over 1,000,000 stars and the best instruments over 50,000,000. These are merely estimates to be sure, but they must be regarded as conservative.

In the star cluster known as the Galaxy, or Milky Way, to which our solar system belongs, the stars are almost innumerable. The better the telescope, and the greater the distance reached in the abyss of space by our perfected sounding-lines, the more millions of stars are added to the known Universe. Yet, all these are but as an atom to those that lie engulfed in the boundless realms beyond.

The distances, even of the stars nearest to us, are simply amazing. Using the diameter of the Earth's orbit, 185,000,000 of miles, as the longest available base line, the nearest star is so far removed, that the parallax ob-

tained is a quantity measured with extreme difficulty with the finest attainable instruments. This work has engaged the attention of competent astronomers for generations, but the results have been meagre. In only a few, perhaps a dozen instances, have even approximate measurements been obtained.

The star known as 61 Cygni, one of our nearest neighbors, has, so far, yielded the most trustworthy results of any, giving a distance from the Sun of about forty billions of miles. Only one nearer star has been found, Alpha Centauri, in the southern hemisphere, at about two-thirds the distance of 61 Cygni. Stars, which from their great brilliancy might reasonably have been thought to be less remote, have failed to show a measurable parallax. Most of the stars are therefore many times farther away.

If, as Herschel assumed, the remote stars taken in mass, will average of about the same actual size and brightness of those in the space near by, then we have a way to make something of an estimate of their distance. The best telescopes penetrate about 1,000 time farther into space than does the unaided eye. If the just visible points seen in a great telescope are 1,000 times more remote than 61 Cygni, we have the enormous distance of 40,000,000,000,000 of miles. Let the curious reader figure out, if he wishes, how long it would take a railway train, a cannon ball, or sound, or light, to traverse that distance.

This is but one-half the diameter of the sphere embracing the limits of our vision in every direction from our tiny earth observatory. Yet, men still continue to egotistically magnify themselves, and to believe that the Universe was created ; and only, or mainly, for the use and pleasure of their pigmy race.

As the distances are too great to be measured, it follows that the real sizes of the fixed stars can only be left to conjecture. This statement receives added force from the fact that no fixed star has yet shown a sensible disk in a telescope. When best defined, the image of the star, though dazzling in brilliancy, is still only a point of light. When we consider the immensity of their distances, we are prepared to believe that many of them must far surpass our sun in size and grandeur. Certainly, Sirius, taking account of its great distance, is in fact many times more brilliant than the Sun. This must also be true of Arcturus, Vega, Capella and many others. At the comparatively shorter distance of 61 Cygni, our sun might be detected by close attention, but it would be an insignificant object among the stellar hosts. The Earth would be invisible with telescopes.

Satellites revolve around planets, planets around the Sun, and the question naturally arises whether the Sun is at rest, or moving with his attendant worlds along a mighty orbit. We have found by direct observation and careful measurement in the case of binary and multiple systems that some star-suns do in fact revolve around primaries, and in a few their periods have been determined. It is more than doubtful if any celestial body could maintain its equilibrium and remain at rest. So far as is positively known all are in motion. They move in an orderly manner around some central body or around a center of gravity common to two or more of them. These systems are themselves moving rapidly through space. If we reason from analogy, we are led to think that they are also in their flight moving in elliptical orbits.

Herschel discovered that our sun is moving toward a certain point in the constellation Hercules. Though the motion is more rapid than that of a ball when fired from

a gun, yet it would take more than a million years for the Sun and his retinue to traverse the distance between us and the stars of that constellation. Accurate instruments prove that the stars toward which we are moving in Hercules are seemingly spreading apart. The problem is like that of a traveler who sees the objects ahead of him becoming apparently wider apart, while of those left behind the reverse is true.

Bessel selected 61 Cygni for an attempt at measurement of distance, because of its large proper motion. Many stars are found to be in motion. The motion seems to be slow, but this appearance is due to their immense distance. It is in reality very rapid, as would be manifest were they near enough to our point of observation. Observations with the spectroscope have comfirmed this view, proving that some stars are moving toward the Earth and others receding. Others, like Sirius, are receding for a period and then approaching. This motion directly in our line of vision could not have been detected by other instruments.

With the meridian circle it was found that Sirius had changed his position 131 seconds in a century. It was also noted that the movement was sometimes less and sometimes more than its mean value. From these irregularities it was calculated that there must be a secondary body revolving around Sirius in a period of about fifty years. The attraction of such a body would account for the disturbance. Some years later the celebrated American telescope-makers, Alvan Clark and Sons, when testing a new eighteen inch object-glass, discovered the companion star. The companion, by an ingenious method, has been found to be half as heavy as Sirius, some seven times as heavy as our sun ; but it is very dim, Sirius being 5,000 times as bright. Here we have a great star performing

the part of a sun for at least one important secondary body which seems to be on the border line between suns and planets.

The variations of Algol are only fully explained by supposing a great dark planet to revolve around him, making a transit across his face at each revolution. In fact this has been proven to be the true explanation. Thus we have arguments stronger than those furnished by analogy, that stars are suns and the centers of planetary systems.

However incomprehensible the number of luminous bodies in the sidereal heavens may be, it must be far exceeded by the number of those that shine only by reflected light. Even in the region of space within reach of the telescope the visible bodies are not a moiety of the majestic aggregate. And there is not in the whole one world, or one granule, in a condition of absolute rest.

We see planets and suns revolving in elliptical orbits, others so far away that we can only determine the direction of their motions, and still others so remote that we are left to infer that they are subject to the same laws of attraction and motion as are those we know.

Calculations as to the weight of certain binary stars, based on their perturbations, indicate that the stars differ in density, as they most certainly do in distance, velocity, size, distribution, color and luminosity. Spectrum-analysis, while indicating the uniformity of the primary material of the Universe, conclusively proves the different conditions and stages of evolution contemporaneously present. Comparatively few bodies have at any fixed times, reached exactly the same stage of development.

Meteoritic, cometary and nebulous matter in the cold regions of stellar space, in widely separated granules, must necessarily be and remain at a very low tempera-

ture if left undisturbed. The particles cool off rapidly, being too small to retain heat for any considerable length of time. But they are all in motion singly or in swarms. They are drawn hither and thither in innumerable collisions. The excitation of heat, and other forms of energy, results in condensation. Nebulæ are formed. The process goes on with increased energy as the distance between the granules decreases, and as the mass is augmented by accessions from a constantly increasing distance. Stars are formed. The process of condensation continues, and the temperature is increased as long as the gain by activity exceeds the loss by radiation. This point is finally passed and the stored energy begins to be lost. After many millions of years the cooling bodies become dark like the Earth.

It follows that the stars would divide into two classes, one, the first in the order of evolution, increasing in temperature ; the other decreasing. Spectrum-analysis so affirms.

Although the fact of the natual evolution of the stars from primary matter could not possibly have been refuted, yet, the timely elucidations and proofs contained in the *Meteoritic Hypothesis* of Sir J. Norman Lockyer, the eminent English astronomer, come with much the same convincing force as did the *Origin of Species* from the pen of Charles Darwin. Astronomy and biology have joined hands.

Lockyer arrives, (among others that are of too technical a nature to be quoted here,) at the following general conclusions :

"All self-luminous bodies in the celestial spaces are composed either of swarms of meteorites or of masses of meteoric vapor produced by heat. The heat is brought about by the condensation of meteor-swarms due to

gravity, the vapor being finally condensed into a solid globe."

"The existing distinction between stars, comets, and nebulæ rests on no physical basis."

"Stars, the temperatures of which are increasing, do not resemble the sun, but consist chiefly of discrete meteoric particles."

"In a single swarm of sufficient magnitude, the ordinary processes of evolution will in time produce successively the luminous phenomena," found in all the seven groups into which he divides the stars.

"The colors of stars follow in orderly sequence through the different groups."

"Double and multiple stars have condensed from double or multiple nebulæ."

"All regular variability in the light of cosmical bodies is caused by the revolution of one swarm or body around another (or their common center of gravity). The revolution of a secondary swarm is an ellipse, and the maximum occurs at periastron ; in the case of condensed bodies the minimum is produced by the secondary eclipsing the light of the primary."

Inconsiderable bodies are in frequent collision. It is therefore not improbable that larger ones occasionally collide, for they are governed by the same laws of motion. The collision of two large bodies, moving with great velocity, developing heat sufficient to reduce both to vapor, would necessarily be followed by a reconcentration, with all the long train of phenomena that naturally follows.

The culmination of the form of energy producing the phenomena and sensation called light is reached in the early middle life of the fixed star, and the highest temperature about the same time. It seems each form of

force reaches a period of its own to which it is adapted; or, to reverse the proposition, when the conditions arrive, the energy assumes the form adapted to them. In other words, matter under different conditions and different degrees of excitation, produces by its inherent potencies correspondingly different sensible results.

Then all the different forms of energy simply and only indicate the various changes going on in the re-adjustment of matter. The life history of a single cosmical body that has entirely cooled off, and returned to cosmical dust, is the type of the universal race of worlds, including any and all manifestations of energy during the life period, from gravitation to the highest intellectual processes. Force, whether vital or other, is a property of matter. The time, degree and character of the evolution of the material determines the kind of force manifested.

The history of the nebulæ and stars proves conclusively that matter, so far from being dead and waiting for some forming power to set it in motion, is eternally teeming with immeasurable energy. An energy so vast and so intense is yet orderly in sequence, forever following the law of cause and effect, along all the branches and ramifications of moving matter.

When we approach a comprehension of the real magnitude and nature of the starry abyss, and begin to get a glimpse of its real significance, we are struck dumb with astonishment at the recollection of the puerile and absurd theories that have enchained the intellect of mankind through all the centuries.

How strange to think that men, comparatively molecular parasites, should assume that all things were made for them, and war upon and slay each other to maintain their "favorite phantoms!" Strangest of all is the fact

that, even up to the present day, many of the crude absurdities are faithfully and sincerely believed in, after their utter falsity has been conclusively demonstrated by countless facts and logical deductions, accumulated by scientific investigation.

Saddest of all, myriads of people still voluntarily court poverty and dire distress, that great and powerful institutions may be equipped and maintained to perpetuate error under the guise of truth. They display anxiety to ignore the truth, and go out of their way to denounce and ostracise those who, without hope of reward, and in spite of refined persecution, endeavor to guide their faltering steps aright.

Fear, crouching in a quagmire of bare possibility that things may turn out in a supernatural way, attempts to pull down the proud figure of Truth, standing on the solid rock of scientific and mathematical deduction through the law of probabilities.

The real question is not what possibly may be, but rather, what in all probability, is true. One proposition appeals to our superstitious fears, born of ignorance; the other to reason and common sense,—founded on observation and experience.

## *CHAPTER VIII.*

## THE SOLAR SYSTEM.

OUR sun is one among the smaller stars belonging to the great, irregularly shaped cluster we call the Milky Way. Along the Milky Way the stars seem crowded in many places, but this appearance is only by reason of their distance from us. Generally speaking, they are probably as far from each other as they are from our Sun. To an observer with a telescope equal to the great Lick refractor, and located on a planet belonging to one of the more remote star clusters, the Milky Way would be barely resolvable into minute points. Among them our sun would remain indistinguishable. To that astronomer the existence of the Earth and her sister planets could only be inferred from analogy. Man, the monad, who has in his ignorance imagined himself the principal object of creation, or a thousand races such as his, would count for naught.

In the preceding chapters we have attempted to gain something of an idea of the processes of sun formation. There is every reason to believe that our Sun is no exception to the rule, in its orderly evolution from the nebulous to its present state. Long after it had become a luminous nebulosity ; it must have filled the space now within the orbit of the farthest planet of our system, and extended millions of miles beyond.

As we return from the sidereal heavens and re-enter our own system, and obtain a nearer view of the methods of nature, the evidence goes to strengthen the nebular hypothesis. The same natural laws have governed here as elsewhere, and the general likeness is maintained. At the same time varying results arising from different conditions are manifest.

Whether our nebulous mass was of meteoritic, or of a gaseous nature, or a combination of the two, or which form of material succeeded the other we do not now consider necessary to discuss. In any case the Sun and planets are here, and in such form, and under such conditions as are fully and satisfactorily explained by natural evolution. It has often been the case that biassed, zealous adherents of a waning faith have wasted their energies in refined hair-splitting, and in raising small distinctions where there were no real differences. This also serves their purpose of distracting the attention of the unwary from the main questions at issue.

There are numerous variations in cloud formation, and in cell division, and in the reproduction of individual plants and animals, as there doubtless are in the initiative and evolution of worlds. The essential truths may be and often are obscured by theological or partisan fog, but they ultimately emerge with renewed splendor in the rays of the surely rising sun of Science.

When the released atoms, molecules, granules, particles, meteorites, etc., had resumed activity sufficient to become luminous, and to re-aggregate, subject to the perturbing influences of a variety of active surrounding stellar masses, there must have been inequalities in the first aggregations. The action of gravitation increased these tendencies, and with collisions, chemical, and electrical action, currents were produced, and rotation

around a common center of gravity became established.

Increased activity led to increased heat and motion. As the rotation became rapid the nebulous mass became round and flattened. External bodies were attracted, and while the mass was yet rare, the planets may have formed in aggregated nebulous masses as indicated by the present appearance of the Canis Venatica nebula. In this case they may have all, or nearly all of them, formed at about the same period. There are some points in the solar system that seem to favor this view. There are a few others which will be considered later, that would indicate that the planets, or some of them, might have been left behind in the form of rings, as in the process of condensation the central mass shrank away from the outside rim.

The period of time required for the formation and final condensation of such planetary rings, in all probability must have been great.

Matter remote from the center of attraction would obey the centrifugal force and concentrate along the outer margin of the revolving mass.

In considering the elements of the solar system, I will begin with the great central luminary from which it derives its name.

The Sun, measured by the accurate methods used by modern astronomers, is distant from the Earth, 92,700,000 miles, and is 865,000 miles in diameter. His density as compared with the Earth is 0.25, and he rotates on his axis in a period between 25 and 26 days. His mass is 331,000 times greater than that of the Earth, and his volume 1,310,000 times greater; gravity at the surface 27.65 times greater.

A million worlds the size of the Earth would not to-

gether make a mass equal to that of the Sun, and 300,000 would not weigh as much. Using a large orange to represent the Sun, the earth comparatively would be smaller than a mustard seed.

The temperature of the Sun is higher than any we can artificially produce, and is estimated at 14,432 degrees F. Substances which on the Earth are solid are known by the spectroscope to be there in a state of luminous vapor, as in other fixed stars. The process of cooling has reached such a point that over thirty-five elements have been recognized in the Sun ; including such well-known elements as calcium, iron, hydrogen, sodium, nickel, magnesium, cobalt, silicon, aluminum, barium, carbon, copper, zinc, silver, tin, lead, and potassium.

To the unaided eye the Sun appears to be a flat circle, but when its magnified image is projected upon a screen, or examined through the colored sun-glass of the telescope, its globular form is unmistakably recognized.

It is seldom entirely free from spots. They appear black, as constrasted with the generally bright surface. These spots are found to steadily move across the face of the luminary, proving that he rotates on his axis, and in the same direction that his planets move around him in their orbits. The same spots, after about thirteen days reappear on the other edge of the Sun. The apparent narrowing of the spots toward the margins of the disk, due to the obliquity of the line of vision, also proves the globular shape of the Sun. The spots may last through several rotations, but they are never permanent. Their changes are often quite rapid in both shape and size. They generally form irregular groups.

The discovery of sun-spots had to be combated, of course. The strange objection was made that the observation scould not be correct because the Sun was made too

perfect to have blemishes. However, we no longer consider the dark spots as blemishes, but rather as evidences of wholesome activity.

A well-developed spot shows a dark nucleus within the umbra and a margin of a much lighter shade surrounding the umbra, called the penumbra. In some there are several umbræ for one penumbra. The spots are generally confined to two zones, one between ten and thirty degrees north, the other the same distance south; they are rarely seen at the Sun's equator, or higher than forty degrees latitude.

Spots show flame like, and at times cyclonic characteristics. They are often of enormous size; many times the diameter of the Earth. They are believed to be similar to storms, causing openings in the luminous envelope, enabling us to look down into the lower and less luminous layers of heavier vapors. This idea seems to be in a measure corroborated by the fact that the spots have a periodical variation corresponding with the magnetic variation of the Earth. The maximum and minimum periods of their variation also correspond with the number of auroral displays, and with the distance of Jupiter from the Sun. The period of the greater number of spots occurs once in eleven years.

Sudden outbursts of activity in the Sun have been followed immediately by magnetic storms here, disturbing the magnetic needle and the telegraph,—even to the extent of enabling lines to be worked without batteries.

The spectroscope indicates a downward rush of vapors in some places in sun-spots, and in other places upward currents. In some cases the velocities of these currents have been measured by its use.

The telescope shows a granular appearance of the general surface of the Sun, and bright streaks called

faculæ near centers of disturbance. Tongues of glowing gas, seen projecting from the surface when the Sun is totally eclipsed, are perhaps profile views of the same phenomena.

These prominences are shown by the spectroscope to be great masses of glowing gas, at times thrown up with surprising velocity, and again having a quiescent, cloud-like appearance. They have been seen to extend 25,000 miles, 75,000 miles, or even 300,000 miles above the surface of the photosphere. This direct and visible evidence of solar energy, must ever awaken our wonder and interest. This phase of solar activity has some connection with the auroral displays, and probably is of use to us in unsuspected ways; and this at a distance from the Earth so great that, as has been well said, in case a child's arm were long enough to touch the Sun, the impression would not travel along the nerves fast enough for him to feel the burn unless he lived to be over a hundred years old.

The Sun as we see and measure it, with the naked eye, is called the photosphere,—the sphere of light we have before our eyes. Outside of this, and discernible when the photosphere is hidden at the time of total eclipse, is the chromosphere, an ocean of incandescent gases, of scarlet color, composed in part of hydrogen, and about five miles in depth. Still outside of this seething mass is the corona, the extremely rare external envelope, of vast extent and irregular and changing shape. The principal constituent of the lower portions of the corona is hydrogen. Our sun then, in composition and general characteristics, does not differ from other stars of its class.

Without the light and heat developed by it, neither plant nor animal life could exist on the Earth. If we

take the egotistical view of these facts that it is for us that all this energy is exerted, that it was made for us, we are confronted with overwhelming evidence to the contrary.

Only a very small percentage of the light and heat fall upon the Earth. The radiation is in *all* directions from the Sun, and aside from what is intercepted by our diminutive planet and a few others, is lost in space. In another sense there is no absolute loss, for the effect is felt by all the particles of matter within reach, even to the fixed stars.

Prof. Langley calculates that the Sun sends out enough heat to warm, at the distance of the earth, 2,200,000,000 worlds like ours. This vast volume of heat and light is constantly poured forth, whether there are any human beings to receive and appreciate its benefits or not. It does not matter; the regular, natural processes go on in their consecutive order.

Not an ounce of energy is ever lost. Passing outward from the Sun, it is arrested and stored in planets, stars, and cosmical dust, again to go through its ever-shifting,—never-ending course.

The cooling off of the Sun is a slow process. The Sun is not in any sense a conflagration. The heat is maintained by the contraction of its mass, and by collisions and friction of molecules and masses near the surface, together with the fall of myriads of meteorites. Heat may also be produced from time to time by chemical combinations taking place on a large scale, when the necessary conditions are reached. It does not seem unreasonable to suppose that the heat may be in part kept up according to the theory advanced by Dr. Siemens, that stellar space is everywhere filled with highly rarified substances, which are attracted inward to the Sun,

are gradually heated as they approach, and finally ignite and produce intense heat at the solar surface. The cooling surface envelopes and helps retain the heat.

The heat generated by contraction alone will be sufficient to maintain approximately the present temperature for millions of years. There has been no appreciable falling off in temperature since records have been kept. If any one in this generation, with his fears abnormally developed by cultivation, feels premonitory chills, let him remember that it is not at all impossible that in time to come some star, escaping from other control may fall to the Sun and replenish his waning powers. There is always room for hope.

Find from the almanac on what days the planet Mercury will reach his greatest elongation from the Sun, and look for him in the early twilight or late dawn as the case may be. It is brighter than a star of the second magnitude, but as it is never more than 29 degrees from the Sun, it can only be seen at times when the conditions are most favorable.

As far as is positively known, Mercury is the planet nearest the Sun. Its average distance from the Sun is 35,550,000 miles. It must be remembered that all the planets move in elliptical orbits, with the Sun in one of the foci; so Mercury's distance from the Sun at perihelion is about 13,000,000 miles less than when at aphelion. Its orbit therefore is a very flat ellipse, and he moves with great velocity, about 109,360 miles an hour. The great eccentricity of its orbit is not its only remarkable feature, for it is inclined to the ecliptic about seven degrees, which is more than that of any of the larger planets.

Its revolution around the Sun is accomplished in 87 days, 16 hours, 49 minutes and 30 seconds. Its diameter

is usually given at over 3,000 miles, but Prof. Barnard, with the fine definition and ample magnifying power of the Lick telescope, makes the diameter two thousand seven hundred and eighty-one and three-quarter miles. Its density, the Earth being one, is 2.23.

It has been supposed that Mercury rotates on its axis in a little over 24 hours. A recent observer thinks its periods of rotation and revolution coincide, as is the case with our moon. This is, however, as yet altogether doubtful, for the best telescopes have failed to show on its surface, markings sufficiently unchangeable and distinct to warrant definite conclusions. Its nearness to the Sun, and to the horizon, and the rapidity of its orbital motion, make it a difficult object to study.

Its distance from our planet varies greatly, because its orbit lies inside the orbit of the Earth. When it is in that part of its orbit between the Earth and Sun, it is nearer by the whole diameter of its orbit than when it is beyond the Sun. As it, like the other planets and the Moon, shines only by reflecting the light of the Sun, it follows that when this side of the Sun, its illuminated surface would appear to us as a crescent, and when on the other side as gibbous or round. When examined with a telescope this is found to be so, and it presents all the phases of the Moon. It also appears much larger when seen as a crescent. This discovery furnished one of the early proofs of the truth of the Copernican or heliocentric theory of the solar system.

As regards the question of Mercury being an inhabited world there is no direct evidence one way or the other. The case stands much the same as it does with the planet Venus, and in this regard the two bodies may be discussed together. Then we may be better able to understand why the great recent telescopes fail to show

much more on Mercury than did the little instrument of Galileo.

No almanac, or directions are needed to identify the planet Venus. It is the morning and evening star,—the brightest of all the retinue, being visible to the naked eye in the daytime. Its light, sufficient to cast a shadow, is too dazzling in the telescope for distinct observation. Its phases are just out of reach of the naked eye, and yield readily to the lowest magnifying powers. It, like Mercury, has no satellite. It being like Mercury an inferior planet, it is never seen in opposition, in fact it is never more than 48 degrees from the Sun. The limits of its elongation, being much greater than in the case of Mercury, proves that its orbit is also farther from the Sun.

Its greatest distance from the Sun is 67,500,000 miles, least distance 66,600,000, and its mean distance in round numbers 67,000,000. These numbers show its orbit to approach nearly to a circle. The orbit inclines to the ecliptic 3° 23′. Its period of revolution is 224.7 days. Its diameter is 7,660 miles. Its density 0.85 that of the Earth, and its specific gravity 4.81 ; that of the Earth 5.66.

It will be noticed that this planet resembles the Earth quite closely in many important respects. Its rotation is supposed to take place in about the twenty-four hour period, but owing to the difficulty of observation it has not been positively determined. In fact here, as in the case of Mercury, our knowledge remains where the early, inferior telescopes left us, as far as the surface of our neighboring world is concerned. We know its various phases well, from slender crescent to full, but little else has been revealed by telescopes.

Yet, with the exception of the Moon, it is the nearest

body in the heavens. At its closest approach it is only 23,000,000 miles away. As in the case of Mercury, proximity to the Sun, and the low altitude interfere with distinct vision, but in a lesser degree. The great brilliancy of the planet is a serious obstacle. There are less of these difficulties in the day time, and some of the best observations are then obtained.

The insurmountable difficulty lies in the atmosphere of Venus, heavily laden, as it always is, with clouds. It is doubtful if the surface of the planet was ever distinctly seen. Very likely the spots and markings sometimes observed, but always dim and unsatisfactory, are inequalities in the density, or perhaps only in the upper surface, of the clouds. This accounts for the remarkable intensity of the light reflected by the planet. Mercury shows the same characteristics in the telescope. Few observers of these two planets will question the opinions of the younger Herschel regarding Venus, that it is the most difficult of all the planets to define with telescopes. "The intense lustre of its illuminated part dazzles the sight, and exaggerates every imperfection of the telescope; yet we see clearly that its surface is not mottled over with permanent spots like the Moon; we notice in it neither mountains nor shadows, but a uniform brightness, in which sometimes we may indeed fancy, or perhaps more than fancy, brighter or obscurer portions, but can seldom or never rest fully satisfied of the fact. We do not see, as in the Moon, the real surface of the planets" (Venus and Mercury) "but only their atmospheres, much loaded with clouds, and which may serve to mitigate the otherwise intense glare of their sunshine."

Observations of the two planets when in transit across the face of the Sun prove conclusively that they each possess an atmosphere. The image of either of these

planets as projected on the Sun is seen with wonderful distinctness,—standing out like a solid globe.

It does not necessarily follow that because these two planets are nearer the Sun than is the Earth, the temperature of their surfaces is very much higher than it is here. The distance from the Sun is not all there is to the problem. The hottest day at noon, go up on a mountain, or in a balloon a few miles and it is freezing, although nearer the Sun. The temperature of interplanetary space is estimated to exceed 400 degrees F. below zero. The heat is developed by the rays passing through the atmosphere and impinging upon the solid earth. More come in than go out, and are retained and stored in earth, water and air. Different conditions of atmosphere, etc., would change the effects. Therefore it is not unreasonable to suppose that it may be as cool, or even cooler at the surface on either Mercury or Venus, than it is here on the Earth.

Then, as to size, temperature, density, atmosphere, elements, aqueous vapors, light, in fact everything necessary to develop and support living organisms, we have no evidence that the planets under consideration are in any important respect inferior to our own. Reasoning from analogy, and taking into the account the known properties of the active material of the Universe, we cannot afford to deny the strong probability that Venus is inhabited. Mercury would have been included in the same sentence were we not rather inclined to think from its smaller mass and greater density, that it may have reached a period when life there is approaching the end or has already become extinct.

In the case of Venus, however, it may be legitimately believed that it has not yet passed the meridian of planetary life. To an inhabitant of that world, if he could

catch a glimpse of the starry heavens through rifts in the clouds, our Earth would appear the brightest star in their sky.

To the astronomer of Venus the Earth and Moon would afford most instructive objects of study. Imagine such astronomer, with his observatory located on a high mountain peak, in the upper regions of the clouds, where a few nights in the year would be clear enough for the study of the stars. He reaches the true theory of the solar system, and measures the planets and determines their distances. His attention is especially directed to the brightest star in his sky, the one whose orbit lies next outside of that of Venus, the one having the conspicuous satellite. When this star is at its nearest point, in opposition, it becomes a splendid object. He names it Terra, or Earth, and determines its mean distance from the Sun. 92,800,000 miles, and its diameter 7,918 miles. Its period of revolution around the sun is found to be 365 256 days. He observes spots and markings upon its surface that he correctly concludes are continents, oceans, and mountains. From these he finds the period of its rotation on its axis. He sees the polar snows and the moving clouds. He is convinced that he beholds in it another inhabited world. He reasons that Earth is in every essential a twin of Venus. The astronomers of Venus had long suspected that their planet was a globe, although it had never been circumnavigated. He could no longer doubt.

He descends from the mountain and reports his discoveries. He was denounced as an heretic, tried before an ecclesiastical tribunal, and publicly burned at the stake. His discoveries tended to weaken faith in certain ancient traditions and authorities, and he suffered for it. If he had admitted that Venus and Earth were both flat

and resting on foundations; and that with his telescope he had seen the foundations of Earth, and the crystal scaffolding that held the Sun, Moon, and "stars also," he would have received the honors of Venus and finally a place among the saints.

Those who think this picture overdrawn will please take notice that it might have occurred about three centuries ago, at the time Giordano Bruno was burned at Rome for heresy. Thanks to Science, there has been much progress in the comparatively brief period since then, and the future is full of hope. We can at last afford to look upon the act of the superstitious, but honest, good people of Venus with forgiving charity. They knew not what they did.

The magnified image of the Earth as seen from the exterior planets, Mars and Jupiter, would in a year pass through all the phases we see in Mercury and Venus, and the Earth would be a morning and evening star to them, never setting far away from the Sun. The future astronomers of Jupiter will put Mercury, Venus, The Earth and Mars, the smaller, inferior planets, together in one class. When the degree of intellectual development we have reached shall have been reached there, speculations as to the habitability of the four little wandering stars will be in order.

The Moon is 240,000 miles from the Earth, and its revolution around the Earth is completed in 27 days, 7 hours, 43 minutes and 11.461 seconds. Because of the advance of the Earth in its orbit the lunar month is about two days and five hours longer. The Moon rotates on its own axis in the time it takes to revolve around the Earth, so the same side is always toward us. Its diameter is 2,160 miles; its bulk 1-45 that of the Earth; and its weight is estimated at about 1-80 that of the Earth.

As the Moon is a dark body, reflecting the light of the Sun, in its revolution it will show when in opposition a full, luminous disk ; when in conjunction its dark side will be toward us ; and between it will be partly bright and partly dark, manifesting all the phases from a slender crescent to the full moon. When it passes through the shadow of the Earth it is eclipsed, and when it comes in a straight line between the Earth and Sun we have an eclipse of the Sun.

Its attraction is the principal cause of the tides. By the law of gravitation it attracts the water on the side of the Earth toward itself, causing the waters to rise, and at the same time attracts the Earth away from the water on the farther side causing high water there also. The Sun and the Earth also assist in producing or modifying the tides.

The common belief that the Moon greatly influences the weather, has not been justified by recorded observations.

The spots on the lunar surface, seen with the naked eye and the earlier telescopes, were supposed to be seas and continents and were named accordingly. All grades of telescopes have been patiently, carefully and skillfully used in the study of this the nearest and one of the most interesting of the celestial bodies. As it contains so much less matter than the Earth, according to the nebular hypothesis, if it began at about the same time it should now be much cooler and further along toward the end of world-life. That such is actually the case we have good reasons to believe.

There are many difficulties in the way of using successfully the highest powers of either the telescope or the microscope. Generally, less than 1,000 diameters will be found more satisfactory than a greater number, even with the largest instruments. Magnified 1,000 times with the

most exquisitely constructed telescope, the Moon would still appear no better than it would to the eye alone if 240 miles away. Yet, a small instrument of only two or three inches aperature, bearing well a power of about 100 diameters, will display hundreds of very instructive features. It would be a waste of time to look for goats, or to make any chicken estimates.

The conclusion is forced upon us that the Moon is not inhabited on the side always turned toward the Earth, whatever may be the case with the other hemisphere.

Occultation of stars by the Moon is of frequent occurrence, and their instantaneous extinction is evidence of the absence of atmosphere. If water was present it would form clouds in an atmosphere. If clouds were present our optical means would make them easily visible; but it is not known that any have been seen. Some observers have thought they have seen a slight haziness and some changes of appearance in a few low places, but if any atmosphere exists it is exceedingly rare; and there can be very little if any water. The absence of seas, atmosphere, vapors, storms and wind, leaves the rocks and mountains unworn and angular; and volcanic dust remains as it falls, forming circles around the numerous craters. These constitute, perhaps, the most striking features of the lunar landscape.

When the Moon is full, the light from the Sun falls straight upon it and we look directly at it. No shadows are cast, and we have a good view of the so-named seas, which are really great undulating plains, that may indeed be the dry bottoms of ancient seas. As the satellite passes through its various phases, we have all the advantages of oblique illumination; the dark shadows of the hills and mountains are brought out with wonderful distinctness, and may be readily measured. Computing

the heights of the mountains from the lengths of the shadows is an accurate process. Objects of much interest are named or numbered, and catalogued and mapped. The perfected methods of photography are producing promising results. In the future any changes taking place may be detected with more certainty.

Tycho, the most striking specimen of the lunar crater-mountain, visible to the naked eye at full moon, with a diameter of 54 miles, and a depth of three miles, with a central mountain nearly a mile high, lies in the exceedingly rough region in the southeast quadrant. Not a level spot can be found near it. It is well to remember that the astronomical telescope inverts the image.

Tycho is the center of the largest system of radiating streaks, which are visible at full moon. These rays pass through mountains and valleys alike, and appear like cracks in the hardening, brittle crust, and as if caused by pressure from the interior; the cracks being subsequently filled with matter of a different color. As far as the shape of Tycho is concerned it can be taken as the type of a numerous class.

There are other enclosed plains without any central cone. Of this class, Plato must not be overlooked. It is located in the northeast quadrant, well toward the pole, at the edge of the great plain called Mare Imbrium. The rampart, as may be seen by its shadow within and outside the plain, varies greatly in height, from 4,000 to 9,000 feet. The enclosed plain is about 60 miles in diameter, and very level. Some observers have thought they detected changes taking place in it.

In the same quadrant, toward the equator, lies Copernicus, a crater 56 miles in diameter, its central mountain having 6 peaks. Its ring, like others, is distinctly

terraced, and rises 11,000 feet. It is also, like Tycho, a center of a region of bright streaks.

To the west of Plato are the mountains called the Alps; and just over the line, in the northwest quadrant, is the Great Valley of the Alps, a cleft over 80 miles long and from four to five miles wide, breaking through the mountains in a straight line. It looks as though a great meteor coming from the northwest had struck a glancing blow and stopped before reaching the large plain. About half-way from this region to the equator is a chain of mountains 460 miles long, the lunar Apennines; the highest peak 21,000 feet.

Of course, clefts are numerous, some of them of great length, with unworn edges and reminding one of cracks in glass. There are faults, and wrinkles, and hills and valleys. The whole globe has an old and wrinkled look.

A remarkable object, probably caused by a fault, one side being lower than the other, called the Straight Wall, or The Railway, a straight line, 60 miles long, in the southeast quadrant some distance northeast of Tycho, is well worth the amateur's time to look up.

The highest mountains are the Leibnitz, near the south pole, at the edge of and a little beyond the limb, 30,000 feet above the surface. I have seen them in profile during an eclipse of the Sun. In comparing lunar mountains with ours, allowance must be made for there being no seas on the Moon.

If we accept George Darwin's tidal theory, the rotation of the Moon during its probable period of habitability was much more rapid than at present.

To me there are no more interesting objects on the Moon than those old circular craters that lie partly in the higher land and partly in the plain. In many instances

the part lying in the plain is partly obliterated, as though it had been worn away by the action of water. In some it is almost entirely wanting, leaving a sort of semi-circular bay. We can hardly resist the conclusion that we here see the effects of the erosive action of water, in the times when there were yet sea. There are objects of interest in profusion for one possessing a moderate sized telescope.

The orbit of Mars is next outside that of the Earth. The mean distance of Mars from the Sun is 141,500,000 miles. Because its orbit is such a flattened ellipse, at times it is only 35,000,000 miles from the Earth ; again, when on the other side of the sun, it may be over six times as far away. Its journey around the sun is performed in 686.95 days. Its diameter is 4,200 miles. Its rotation upon its axis takes 24 hours, 37 minutes, 22.73 seconds. It may be distinguished from the other planets by its decidedly red tint.

In 1877, Prof. Hall, with the large Washington telescope, discovered that Mars has two satellites. One revolves about 4,000 miles from the surface of the planet, in a period of 7 hours, 39 minutes ; the other at about 12,500 miles, in 30 hours and 17 minutes. They are very small, among the smallest bodies in the solar system, probably not exceeding 20 miles in diameter.

Except when Mars is at its nearest opposition, and with favoring conditions, it is a rather unsatisfactory object with small telescopes. Yet, with such instruments the spots may be unmistakably seen. Observations on this planet, even when the best instruments are accessible, are rather contradictory, as far as details are concerned.

Its ruddy color is seen to be caused by the color of the continents, and has been thought by some observers to

be due to the color of the soil, by others to red vegetation, or both. The nature of the so-called seas is yet a matter of doubt; they are said to appear more like an uneven country through the Lick telescope, and the straight lines were not seen, and the alleged signal resolved itself into a mountain peak.

There are unquestioned features resembling those of our planet; the seasons, the atmosphere, the clouds, the ice-capped, polar regions, with the presence of water. The aqueous vapor no doubt accounts for many discrepancies in observations. It is evident that seas, continents and canals would be often obscured by the clouds.

With the optical difficulties attending the atmosphere of the Earth, augmented by another atmosphere,—that of Mars, negative testimony loses much of its weight, and the positive evidence of those skilled observers who have seen appearances indicating the presence of a system of "canals," cannot be ignored. Whether these or any other observed features are artificial or not, remains to be proven.

Taken all together we must regard Mars as probably an inhabited world, and very similar to the Earth. The area of its seas is much less than those of the Earth, and its habitable land surface lying mostly in and near the equatorial zone, has nearly as great possibilities of population, notwithstanding the smaller size of the planet.

Its seas are very likely reduced in extent from their former limits by the absorption of water, for Mars is farther advanced toward planetary old age than the Earth. If there were parts of old ocean beds already dry, it would tend to reconcile some conflicting observations.

It is a legitimate presumption that Mars reached its habitable stage long before the Earth was fitted to sustain life, and therefore its present inhabitants have had

a longer period in which to develop. Let us trust that they have long since outgrown creed and greed, and the inequalities, intolerance, persecutions, oppression, wars and suffering that arise therefrom ; if so, there would be hope for us.

Between the orbits of Mars and Jupiter there is a ring of minor planets called Asteroids, of which some 400 have been discovered. The first to be discovered were Ceres, diameter 569 miles ; Pallas, diameter 273 miles, and Vesta, diameter 237 miles. All are small, and their orbits near each other, and averaging about 250,000,000 miles from the Sun. When nearest to the orbit of Mars one of these little bodies comes within about 21,000,000 miles of it.

The theory was early advanced that these Minor Planets were fragments of an exploded planet of considerable size ; but it is questionable about this being the true explanation.

It seems probable that they have naturally formed from rings of nebulous matter, or of meteorites, revolving around the Sun. This view is strengthened by the now conceded fact that the rings of the planet Saturn are composed of an innumerable number of minute solid bodies. Doubtless many more of this group remain undiscovered.

Passing on to the distance from the Sun of 478,000,000 miles we come to the path of Jupiter, the largest planet of our system. His diameter is 87,000 miles ; period of revolution 4332.58 days ; mass 300 times that of the Earth, and its volume 1,300 times greater. Its density is about the same as that of the Sun ; nearly one-quarter that of the Earth. It rotates on its axis in the short period of about 9 hours and 55 minutes.

To the naked eye, Jupiter is only second in brightness

to Venus. It can be readily identified by the four bright satellites, visible with almost any little telescope. An ordinary telescope will show its disk flattened at the poles, and will also show broad, tinted belts across the disk parallel with the equator. These belts are evidently clouds, drifting and irregular, stretched along in line with the planet's rapid rotation. The belts are usually described as red, sea green, brownish, coppery, pale blue, brick-red, yellow, green and purple; the ruddy tints predominating, especially near the equator. In 1879 a great red spot appeared, remaining for years. It is supposed that here as in the Sun the equatorial masses of vapor revolve faster than those nearer the poles. It is evident that the denser body below is seldom seen, whether through the darker or lighter portions of the vapory envelope. Perhaps it was seen partly unveiled in the great red spot.

Jupiter and his four large moons look like a miniature solar system when viewed with low powers. The fifth satellite, discovered by Prof. Barnard with the Lick telescope, can only be seen with fine instruments.

The first satellite revolves around Jupiter in 1 day, 18 hours, 28 minutes, and is 2,450 miles in diameter. The second revolves in 3 days, 13 hours and 14 minutes, diameter 2,045 miles. The third revolves in 7 days, 3 hours, 43 minutes, diameter 3,558 miles. The fourth in 16 days, 16 hours and 32 minutes, diameter 3,345 miles. The fifth has a period of revolution of 11 hours and 57 minutes, its distance from the surface of Jupiter is 67,000 miles, from his centre 111,910 miles, and the satellite is over 100 miles in diameter. The measurements are given as determined by Prof. Barnard with the Lick refractor. The mean distances from their primary of the four large satellites are I. 259,000 miles,

II. 414,000 miles, III. 647,000 miles, and IV. 1,164,000 miles. All the satellites have a greater mean density than Jupiter. The satellites are frequently occulted by the planet, and they are also often seen in transit as bright round spots. Again the shadows of the satellites may be seen black and round crossing his disk, or the satellites may suffer eclipse by passing into the shadow of the great planet.

The third and fourth satellites as seen by Prof. Barnard, in the 36-inch Lick refractor, show large diffused markings, and white polar caps exactly like those of Mars. These observations by Prof. Barnard go to sustain the theory that the satellites of the large planets are near to, or passing through, their period of habitability. If the polar spots are due to ice and snow, as they are presumed to be in the case of Mars, and there is no reason to doubt it, then these satellites have atmosphere, and aqueous vapor. The white caps being confined to the polar regions, shows the temperature to be high enough to sustain life. A presumption is therefore raised that they are inhabited worlds.

## *CHAPTER IX.*

## THE SOLAR SYSTEM, CONCLUDED.

SATURN, shining with about the brilliancy of a star of the first magnitude, may be recognized by his pale steady light. Any one whose anticipations have not been unduly aroused by fine pictures of the planet, when viewing it for the first time with the telescope, will not fail to feel pleasure and admiration. It is a grand telescopic object. The globe itself shows very much like Jupiter, only smaller, paler, less flattened at the poles, and the belts less distinct. There have been spots of sufficient permanency to enable the rotation to be approximately determined, but as is the case with Jupiter, it is probable that no vision has ever penetrated the deep layers of vapor.

The superb system of rings by which the globe is environed, is unique in our planetary system. They are not indistinct and nebulous, but shine with the pale lustre of the body of the planet. A view through a moderate telescope, of the planet, his rings when open, and his eight satellites, or as many of them as may be visible at the time, is well worth a journey to see, and when rightly understood, will convey a most instructive lesson.

The average distance of Saturn from the Sun is 884,000,000 miles, its mean diameter is 71,000 miles, and it rotates on its axis in about 10 hours and 14 minutes. Its year is equal to 29 and 1-2 earthly years. Its density is only one-eighth that of the Earth.

There are three principal rings; the one on the outside is about 150,000 miles in diameter. Minor divisions have been seen in all the rings. They were for a long time supposed to be solid, but a portion of the body of the planet has been seen through the inner ring. They lie in the plane of the planet's equator, are very wide and extremely thin, and it has been demonstrated that they could not maintain their positions if solid, and it would be at least doubtful if they could were they liquid or gaseous. This difficulty would be removed if they were assumed to be composed of small particles, or meteorites, and the spectroscope confirms this view. The planet itself is lighter than water, and is still at a high temperature, as was our earth many millions of years ago.

We have then in the Saturnian system several stages of world growth in the same field of view in our telescope, and all confirming the hypothesis that furnishes the only natural explanation of their existence.

The satellites are named Japetus, Hyperion, Titan, Rhea, Dione, Tethys, Enceladus and Minas, and their orbits are nearly on the same plane as the rings. Titan is the leader, and as measured by Prof. Barnard is 2.523 miles in diameter, and is 5.2 times as dense as Saturn. Titan revolves around its primary in 15 days and about 23 hours, at a distance of 781,000 miles from the centre of the planet.

To the inhabitants of these satellites, if any there are, their nocturnal sky must offer a spectacle of wonderful beauty and grandeur.

At one stage in their intellectual development the inhabitants of Titan must have held that their little moon was the fixed and solid center of the Universe, created for them; and Saturn and his other attendants, (a resplendent retinue,) and the mighty rings, the Sun,

planets, and the "stars also," were made to give them light. Could they not see them, all these hosts, with their own eyes, revolve once in each of their days around their home? Such was the thoughtful care of the unknown being they worshipped. They were zealous to persecute and torture the poor heretics who dared to deny it, and to affirm that the phenomenon was due to the rotation of their own tiny moon. Of course it took a man-like god to plan and construct such a mechanical Universe. This belief came to be the foundation of their religion. Often pernicious effects continue long after the initial causes are removed. Religions, profitable to a ruling class, die hard; they have nine lives. The cosmogony and theology of the Titans were just as reasonable as those of the ancients we revere. Even in this advanced age of Titan they may continue to willingly pay from their hard earnings—means to be used to perpetuate their own follies and fears. This is indeed to kiss the rod that smites them.

The supernatural has a place in the line of evolution, but it is low down toward the foot.

Uranus, the next planet to Saturn, barely visible to the naked eye, was not known to the ancients. It was discovered in 1781, by Sir William Herschel, with his great reflecting telescope. Its distance from the Sun is 1,781,900,000 miles; diameter about 31,000 miles; sidereal period about 84 years; volume 65 times the Earth; mass 14.7 times the Earth, and its density 0.22 that of the Earth. Little has been learned about it by telescopic observation, and its period of rotation is unknown.

Herschel thought it was attended by six satellites, but only four are positively known. Their orbits lie at right angles to the path of the planet; the only instance

of the kind in our system. They are also said to revolve in a retrograde direction. The Lick telescope proves the rotation of the planet by showing that it is flattened at the poles. The eccentricity of its orbit is considerable, the greatest distance exceeding the least by 163,000,000 miles. Huggins, from spectroscopic observations, suspects the presence of large quantities of hydrogen in the planet's atmosphere.

Neptune is the most distant planet of the solar system, yet discovered. Irregularity in the movements of Uranus led M. Leverrier, in France, and Mr. Adams, in England, to independently inquire into their cause. Each arrived at the result that the perturbations were caused by the attraction of an unknown planet, and indicated its probable location in the sky. Leverrier communicated the result of his calculations to Dr. Galle of Berlin, who discovered the planet with his telescope within a degree of its calculated postion. The mean distance of Neptune from the Sun is 2,791,000,000 miles; its diameter is about 33,000; its time of revolution around the Sun about 165 of our years; its mass 17 times that of the Earth; its volume 85 times and its density 0.20 that of the Earth. It is known to have one satellite, supposed to be the largest of its class. Nothing is known of its rotation. The eccentricity of its orbit is less than that of any other planet, excepting Venus and some of the minor planets.

Comets have been until,—well, perhaps this century, the innocent cause of no little fear and superstition. They were looked upon even by the learned, up to a few centuries ago, as of baneful effect,—the harbingers of war and pestilence. It is only recently that astronomers have begun to understand their nature. Comets, like eclipses, have inspired the ignorant with abject

fear. Even Josephus believed a comet to be an omen of the destruction of Jerusalem. Such notions do not seem so absurd to those who, knowing little of nature's ways, habitually ascribe almost every phenomenon they may be unable to explain, to supernatural agency. Almost anything was easy to people so credulous as to believe that the Earth ceased to rotate, or turned back. (Sun stood still for nearly a day for Joshua, and the shadow returned ten degrees on the dial of Ahaz to convince king Hezekiah,—Bible.) Weigh all things, carefully, with the steadiness of courage, and with an even balance.

The work of science in clearing and making easy the paths for unwilling and faltering feet has been Herculean ; but it has been and now is a labor of love.

Conspicuous comets are not common, but nearly every year several telescopic comets are added to the list. The number of these wanderers that have passed around the Sun has been estimated at thousands and even millions. In searching for remote comets, or in examining large ones, the larger aperture should be used and the lowest eye-piece.

Comets vary greatly in size, brilliancy, length, and shape of tail, rapidity of motion, etc., and the same one may change perceptibly in a few hours. They are very light ; their attraction not being sufficient to cause perturbation when they pass near the planets. The orbits of several have been computed, while others are of long or unknown periods, if indeed they ever again visit our system.

Their tails develop as they approach the Sun, pointing away from that luminary. After its perchelion passage, which is very rapid, the tail of a comet will still point away from the Sun. The tail seems to be driven

away from the nucleus and its envelope by some repulsive force of the Sun. A force that as we might say discriminates, attracting the heavier, perhaps solid, nucleus, and the inner part of the envelope, while repelling the lighter material of the outer part of the envelope, and the tail; as though there was an outgo of one form of solar energy, and an intake of another answering to gravitation. Some think that there is electrical repulsion in this case.

Stars may be seen shining unaltered through the tails of comets, or even through the heads quite close to the nuclei. Comets are therefore composed of extremely attenuated material.

The testimony of spectrum-analysis seems to prove them to be swarms of small meteorites. This would accord with the observations showing them to shine in part by reflected light, and the collisions of the particles would develop some luminosity.

Halley's comet, a very bright one, has appeared several times, its last appearance being in 1835. Its period is about 75 years, and it will be next due in 1910. Encke's comet has an orbit nearer the Sun than Jupiter's, and a period of revolution of only about three and one-third years. Biela's comet has a period of six and one-half years. The celebrated comet of Donati, that appeared in 1858, will be again looked for in about 2,000 years.

The comets that either move in parabolas, or in very elongated orbits often pass close to the Sun; some perilously so. They seem to come from outside our planetary system. They are generally of great beauty and brilliancy for a few days after passing the Sun.

Among the great comets of very recent years may be mentioned those of 1858, 1862 and 1882. Few, if any,

comets have been seen in modern times surpassing in interest the great one of 1882. It was so bright as to be visible in the day time when near the Sun. It appears to have passed that luminary only about 300,000 miles from its surface. Its period of revolution is nearly 800 years.

The comet of 1744 had 6 tails; and Biela's comet divided into two, both visible in the same telescopic field of vision and each having coma, nucleus, and tail.

Meteors, aerolites, or shooting stars were regarded with wonder and superstitious awe in ancient times, and it is related that meteoric stones have been preserved in churches and temples as religious relics. One is mentioned by Pliny, which fell in 467 B. C., in Thrace; the size of a wagon. In 1492, one fell in Alsace, weighing 260 lbs., which is still preserved in the church of Ensisheim. At Mecca, is the "black stone" which is believed to have been brought from heaven by angels. It is about 7 inches in diameter, and Burton says it appeared to him like a common aerolite. It is worn smooth by the lips of the worshippers who have reverently kissed it. There was a shower of stones in Crema in 1511; 1200 pieces were collected.

On April 26, 1803, at Aigle, in France, a number of stones fell, the largest weighing 20 lbs. There have been hundreds of authentic cases recorded. A meteoric stone in the Smithsonian institution weighs 1,400 lbs. May 10, 1879 there was a meteoric fall at Esterville, Emmet county, Iowa. A fragment penetrated the ground 14 feet. A number of pieces were found; one weighed 431 pounds, another 170 pounds, and all that were found made 640 lbs.

Hundreds escape from the Earth's attraction and pass on their course. Kepler was right when he thought

interplanetary space as full of comets and meteors as the ocean with fish. Meteoric stones differ very much : some are stony, some metallic and some mixed. Iron, nickel, silicon, tin, and, in all, some twenty-two elements have been found in them.

Any clear night meteors may be seen, most of them so small that the heat developed in passing through the atmosphere burns them up while still high in the air. There are a few larger ones, but, generally speaking, they are mere particles of meteoric dust.

There are several known periodic meteoric streams that the Earth passes through in its yearly course. One encountered on the 14th of November each year gives a fine display of meteors. These November meteors are called Leonids because they radiate from the constellation Leo. In a period of about thirty-three years,—Nov. 13th to 15th, 1833 and 1866, there have been magnificent displays of meteoric showers. It has been found that the meteors travel, unevenly distributed, in an orbit around the Sun ; and the important fact has been announced that the orbit substantially coincides with that of a known comet. Thus every year the Earth comes in contact with this stream of cometary matter, and with like individual meteors constantly. There are many other meteoric periods. About August 10th, meteoric streams connected with Comet II, 1862 ; November 27th to 29th in the path of Biela's comet ; April 20th, Lyrids, from the constellation Lyra are seen. There are now more than 100 meteor systems, named from their radiation points. There are more in August than in any other month. The number, though great, visible in a year from any given point, is but a small portion of what could be seen from every part of the Earth, land and sea ; and they fall just the same whether

hidden from sight by clouds or the brightness of the Sun, or where there are no eyes to see. Their numbers are simply incomprehensible; even those that come within the Earth's attraction. Then how vast the numbers contained in the space once filled by the solar nebula, to say nothing of interspellar space.

The Zodiacal Light is a triangular track of light seen after sunset and before sunrise, stretching up from the horizon near the Sun, and extending upward of 50 degrees. Its axis corresponds with the ecliptic. It fades away at each side and toward the Zenith. There have been several theories advanced to account for it; one that it is a solar atmosphere, and another that it is a ring around the Earth; although plausible, both theories encounter fatal objections.

The theory generally adopted by astronomers is that of Laplace, the originator of the nebular hypothesis. "If in the zones abandoned by the atmosphere of the Sun there should be any molecules too volatile to be united to each other or to the planets, they ought, in continuing to circulate around this star, to offer all the appearances of the zodiacal light without opposing any sensible resistance to the different bodies of the solar system, either on the account of their extreme rarity, or because their motion is nearly the same as that of the planets with which they come in contact."

All the conditions seem to be met by supposing the zodiacal light to be caused by a multitude of minute meteoric bodies traveling in elliptical orbits around the Sun. The variabilities noticed are all explained on this theory, and it also appears to be verified by the spectroscope.

The Aurora Polaris, or Borealis, nothern lights and southern lights, is undoubtedly caused by disturbances

of the Earth's magnetic and electrical conditions. These displays have an eleven-year period corresponding with the solar activity indicated by the sun-spots. The magnetic attraction of the Earth would be likely to bring within its influence clouds of impalpable meteoric dust, principally containing iron. At periods of great activity or at times of sudden restoration of equilibrium, the more volatile molecules of the dust might be repelled by the radiating energy, as in the case of the tails of comets, as they approach the Sun. If this theory is correct, the colliding meteoric particles should develop and for a brief time retain, luminosity ; in great displays where a corona is formed, this seems to take place on a large scale. It is probable that every planet and floating particle in the planetary system responds to the magnetic thrill in sympathy with the solar disturbances.

A review of the facts relating to the solar system compels the conclusion that the nebular hypothesis of Laplace as modified in some details by later discoveries, is the only rational explanation. The facts throughout are confirmatory of the correctnesss of the hypothesis.

In the planetary system, no two bodies are of the same magnitude, and they vary in size from the Sun, down to invisible atoms. There is a vast difference in mass and volume between the Sun and Jupiter ; between Jupiter and Mercury ; Mercury and the smallest minor planet or the moons of Mars, globes some ten miles in diameter ; and between these and the smaller meteorites. Yet, a molecule a thousand times smaller than a pollen grain may be, as far as orbit, sidereal period, rotation and uniformity of motion are concerned,—an independent planet. Space is well occupied with moving bodies of all grades. Many have condensed from nebulous matter,

as have the planets, while others from outside the solar system are as we have good reason to believe,—the dust of dead and disintegrated worlds. Only a moderate proportion of the diffused particles is congregated in comets, meteoric streams and zones.

We have followed the chain of evolution from nebula to star, in the general way, and came near home to study the evolution of the solar nebula through the same natural processes into a considerable number of planets and their central star. The internal mass of Jupiter still at red heat, glows through the masses of hot vapor in his atmosphere. We shall see that millions of years ago the Earth was in the same condition, and that barring accidents, millions of years hence Jupiter will become cooled and habitable. The Sun is helplessly following the same course. Jupiter has comparatively recently ceased to be a self-luminous body. Saturn, Uranus and Neptune, though cooler, are still far from being in condition to sustain life—such as we are familiar with.

There may be beyond the orbit of Neptune, planets yet undiscovered; and it would surprise no one to have the observations of Profs. Watson and Swift, of a planet or planets inside the orbit of Mercury, confirmed.

Several observers have at different times seen unknown, round bodies cross the disk of the Sun. July 21, 1896, Prof. Brooks saw a dark, round object cross in front of the moon; probably a very large meteor.

The zone of minor planets probably contains enough material to form one planet about the size of Mars, but when this space was occupied by a nebulous ring, instead of forming one large planetary body as was the case with the principal planets, probably through the effect of the attraction of the large exterior planets, numerous centers of aggregation formed. In the formation of planets as

well as hail stones, there are widely differing results, arising from slightly varying conditions.

Differences and imperfections are found among the trees of a forest, and the same, and from much the same determining causes, among the bodies in a wilderness of worlds.

In the system of Saturn eight secondary planets have been formed without a doubt in the usual manner, from nebulous rings; but there yet remain rings of probably substantially the same material, delicately balanced by the attraction of the planet and his satellites, and showing no signs of change. Perhaps the requisite conditions for assuming the globular form may never be reached, or, possibly while the reader of these lines still lives, a passing cometary-meteoric swarm may come in contact and arrest the orderly movement of the molecules of the rings, and the heat developed by the clashing particles, aid in the formation of a secondary planet before our eyes.

In no very material respect would such an injurious or beneficial occurrence differ from the fall of a mature oak before an autumn blast, scattering acorns, the germs of future beautiful groves, while at the same time bearing down many a young and vigorous tree to untimely ruin.

Meteors are drawn from their orbits and rain upon the Earth and all the other planets; they collide with each other, and where governing principles are the same, such events may occasionally take place on a larger scale among the larger cosmical bodies. In all the Universe no preventing hand is ever raised.

## *CHAPTER X.*

## THE TERRESTRIAL CRUST.

MANY millions of years ago when the Earth was a hot and liquid mass like the large planets are now, a seething mass of vapor enveloped the whole globe, cooling on the exterior, falling in places under the force of gravitation, to be again forced upward by the internal heat energies, and swept and tossed by violent storms. The rotation of the Earth was much more rapid then, than now, and the vapors as seen from Mars, lay in belts parallel with the equator like those of Jupiter.

A time was reached in the cooling process when the surface of the liquid mass began to solidify. Probably the first solid crust fields were broken up by the constant agitation, sank in the lighter fluid and remelted. Ages passed, and at last a more enduring crust was formed upon the thickening liquid, and the pent up vapors found vent through numerous fissures. The struggle between the cold without and the heat within, went on. The cooled and condensed vapors fell in continual showers, only to be instantly again converted into steam.

The attraction of the Moon, then nearer the Earth than at present, caused bodily tides that rent and displaced the rising and falling crust. Overflowing matter solidified and strengthened it for the next tidal wave to break. It was a long and tedious process before the crust became cool enough for the rain to gain upon the evaporation and allow pools and little lakes to form.

The heavier liquids gravitated to the center of the planet, and the crust formed from the lighter surface strata. The crust, broken by escaping gases, and rent by tides and currents would be filled with pores and cavities like lava or bread. Such cellular rock would not sink to any considerable depth. Although the center of the planet would be a dense liquid, or possibly solid nucleus, there would be and remain for an enormous period, between that and the surface crust, a great depth of matter still in the liquid state.

As we descend in mines and wells, it is found that the temperature averages about one degree higher for every fifty-three feet of descent. Most rocks would be fused at the temperature given us by this rate of increase at a depth of twenty or thirty miles. Since the fusing point is higher under pressure, it follows that the crust must be thicker than these figures indicate. The peculiar motions caused by earthquakes, and volcanic eruptions of lava, are sufficient to convince common people that the crust we dwell upon is none too thick ; in fact, a greater degree of stability would not be objectionable. Even 50 or 100 miles would be a thin stratum compared with the diameter of the earth.

Many facts go to prove that the crust is falling in places, rising in others, wrinkling, cracking, and generally becoming adjusted to the gradually decreasing volume of the cooling and shrinking interior. That the contents of the interior of the Earth are in large part liquid, and at a high temperature, is not seriously questioned.

The space at our disposal will no more than suffice for a too brief outline of the interesting subjects connected with the history of the Earth's crust. I earnestly recommend the readers who have not already done so, to obtain

some late, standard work, devoted exclusively to geology, and make comparisons with their own observations. The busy man could find time, that perhaps he now wastes; there are evenings in plenty, and fifty-two Sundays in a year. Five hundred full days of Sundays in ten years, if well improved, would enable a man of average mental capacity to store up a large fund of useful scientific knowledge, that would draw the teeth and dull the claws of supernaturalism. Try it.

Several scores of millions of years ago, when these primary changes were taking place, the length of the day, as has been shown by calculations, must have been less than a quarter of what it is now, and the Moon was only some 25,000 miles from the Earth. The time of rotation of the Earth and the distance of the Moon have gradually lengthened under the influence of tidal action, as has been shown by George Darwin. All this must be considered in imagining the then prevailing conditions.

After the crust had become permanent, it remained for ages at red-heat, and the atmosphere was charged not only with aqueous vapor, but with many of the more volatile and gaseous elements. The first lakes were formed of boiling saturated solutions. Chemical changes were going on, and in the direction of the more complex, as it had ever been during the evolution from the nebula.

It is not probable that any portion of this original crust is now exposed, or in any way accessible to geologists. It does not matter, for the changes wrought by the action of the various forces would have prevented recognition.

The crust has continued to increase in thickness by crystalizations upon the interior surface from the cooling liquid mass, from matter ejected by volcanic action, and from the fall of meteors and meteoric dust from the region outside our atmosphere. If the rocks lay undisturb-

ed in their original positions, men could only examine the surface and the few hundreds of feet reached in mines and borings, but the upheavals have left them inclined at all angles, from horizontal to perpendicular. It is estimated that geologists have found and examined in different places strata of rocks with edges thus brought to the surface, equivalent to fourteen miles in thickness of the terrestrial crust. From their positions and surroundings, by numerous comparisons, their order of succession has been determined.

During the last half of the closing century this great book of nature, a true revelation of the rocks, a record of the Earth's history engraved in stone, has been well and carefully thumbed. In this enduring record, not made by human hands, containing no ambiguous manuscripts of uncertain authenticity, many lessons have been learned that will continue to influence thought, through all the generations.

For the sake of convenience, geologists have made five main divisions or eras of the geological record and the geological time :—(1) Archæan ; (2) Palæozoic ; (3) Mesozoic ; (4) Cenozoic, or Tertiary ; and (5) Quaternary, or Post-tertiary and Recent. Each of these main divisions is further subdivided into periods or systems, and the periods into formations.

The Archæan are the oldest known rocks, and constitute the first chapter of the history of the Earth as preserved to us. As they now are they offer no evidence of having once been a part of the original crust. Considering the changes wrought by heat, pressure, and the action of the elements, during probably not less than 100,000,000 years, it would not be expected that original features would be retained.

The rocks of the Archæan era pass below into the gran-

ite, and consist largely of gneiss, have a stratified character, are of great extent and thickness, and represent well toward half of the time passed since they began to form. They were made up of the debris of the earlier rocks, worn down by rains, streams, tides, winds, changes of temperature, chemical action, etc., and deposited as sediment in the ocean. In time they were elevated as other portions of the globe were depressed, and became dry land; and the sediment dried and hardened into solid rock. All geological changes, or nearly all, are brought about slowly, and by these steadily acting natural causes, and require vast periods of time.

The strata embraced in the Archæan, includes the Laurentian system, which in Canada is estimated to be 50,000 feet thick. Large quantities of iron are found in these strata. The internal heat of the Earth has metamorphosed this mass of rocks, and burned out or altered beyond recognition the organic remains it doubtless once contained.

It was in the great period during which these strata were being deposited, that life must have originated upon the Earth; unless, indeed, it began in a preceding age. Along the shores and lagoons, and amid the deposits and chemical changes of the warm primeval ocean, conditions were more favorable than at any later period for the formation of colloid compounds, and protoplasm; "The living matter from which all kinds of living beings are formed and developed, and to the properties of which all their functions are ultimately referred." The step was comparatively short from unstable, jelly-like chemical compounds with gently active properties, to the unstable jelly-like chemical combination known as protoplasm, that displays, as in the Amoeba, slowly and faintly, the properties of motion, and dawning sen-

sation, or as in the Desmid assimilation without apparent sensation. In many instances, under the highest and best powers of the microscope living protoplasm does not show structure, but is to all appearance without organization. In other specimens simple structural indications are noted. If we yet have living protoplasm near the dividing line, it would be presumptuous to deny the existence of still more simple living matter in the first lagoons, differing but slightly from its sister non-vital substances. We are considering two slightly different forms of matter, possessing as properties two slightly differing forms of energy,—one of which is known to us as vital force.

There has been found in the Laurentian rock a peculiar structure that has led to a long discussion and much difference of opinion among geologists. One side, and among them are some very able microscopists, contends that the Eozoon Canadense, as it has been named, was an almost formless, branching, chambered, protoplasmic animal mass that grew on the ancient ocean bottom, and secreted a protecting coat of lime, that now forms the walls between the tubes or chambers. This view is rendered more probable by the presence in that early age of iron-ore, graphite and lime, almost sure evidence of the existence of living organisms. Coal is of vegetable origin and its metamorphism produces graphite. The more recent lime formations are composed almost wholly of the shells of lower animals. Again, the Eozoon Canadense is a primitive form such as could have been expected to flourish in that early age. There are other geologists, perhaps equally competent, who, admitting that this object has some peculiarities of structure, yet it so closely resembles some known mineral formations, they consider the proof of its animal

origin insufficient. The controversy in itself might be taken as evidence that it helps to bridge any alleged gap between the highest mineral and lowest organic forms.

The vast amount of sedimentary rock found, indicates a like amount of other rock ground up and disintegrated into mud and washed into the ocean. This process being constantly going on, it follows that the same material has gone through these changes many times. Rock, when elevated to the surface, becomes subject to erosion. In any locality there will be many long gaps in the geological record—for fossils are destroyed with the strata. Such a gap intervened between the Archæan system and the Palæozoic, and it was of great duration. Future discoveries will doubtless help to connect the history by filling up this vacant place as others have been filled in the past.

It is not likely that any remains of the first living organisms will ever be found ; they were simply naked protoplasm, without any hard parts capable of permanent preservation in a fossil state.

The Palæozoic era is also called the Silurian Age or age of invertebrates. The processes of evolution had been going on in the long interval, and the newer age opened with more highly developed animals and plants.

The many thousands of feet of strata were formed of sediment deposited in shallow water,—and of course during a long continued gradual subsidence of the areas covered. During the earlier part of the era the highest animal life that appeared is represented by chambered shells, and in the later period, the lowest forms of vertebrates appeared.

The Palæozoic rocks are divided into the Silurian,

Devonian, Carboniferous and Permian systems. The vegetable fossils of the Silurian system consist of low forms of sea weeds, and the animal fossils as yet found and undisputed are Foraminifera, Sponges, Hydrozoa, Corals, Crinoids, Cystidians, Star-fishes, Sea-worms, Trilobites and molluscan shells of several kinds.

Next came the Devonian with ferns, club-mosses, horse-tail reeds, and traces of pine; land snails, insects, a low type of fish similar to the sturgeon, together with trilobites, corals and molluscs more highly developed than those of the preceding system.

The next great division of the Palæozoic, the Carboniferous, is so named from the extensive coal beds then formed. There were also thick limestone deposits made up largely of corals, crinoids, polyzoa and other calcareous or lime building organisms. Coal is composed of altered and compressed beds of vegetation. Each bed of coal is generally underlain by one of fire-clay containing roots and other evidences of having once been a surface soil, probably in a marshy swamp. The accumulated vegetation submerged during subsidence, was covered with other material. The period of time during which the changes were going on was of incomprehensible duration, but none of the higher orders of plants and animals had appeared. The flowerless plants reigned almost as the sole representatives of the vegetable kingdom; but instead of being small like their descendants of the present time, were of gigantic size. Plants resembling club-mosses were sometimes 50 feet in height. There were dragon-flies, crickets, ants, amphibians, king-crabs, and large sharks; the trilobites died out and did not make their appearance in the succeeding period.

The Labyrinthodonta of the Carboniferous period

were amphibious, forming a connecting link between the primitive Sauroid fishes and the saurian reptiles which succeeded them.

Already a number of organic forms had become less fitted for the conditions than were their rivals and enemies—and had therefore become extinct. The fittest survived in the struggle for food and life.

In the Permian period there was a gradual transition; among animals toward the reptilian type, and the conifers among plants became more marked, and palms appeared. The first reptiles were derived from the amphibians and through them the lowest mammals originated.

The Mesozoic era was essentially the age of palms and reptiles. It is divided into three subdivisions: Triassic Jurassic, and Cretaceous. In the Triassic period there were cypress-like conifers, palms and tree-ferns, early types of lizards, reptiles with beak-like jaws, animals intermediate in structure between reptiles and birds, while in size they resembled elephants and crocodiles. There appeared also the first and lowest of mammals resembling the marsupial animals of Australia. Beds of rock-salt were deposited in the briny enclosed seas. From the saturated saline waters were deposited in succession: (1) The least soluble salt, sulphate of lime; (2) Common salt or chloride of sodium; and (3) Chloride of potassium and magnesium. Rock-salt is not confined to the Triassic periods, but has formed in every geological period including the present, for it is forming now.

During the Jurassic period, a few animal forms became extinct, while many others continued to change along the line of development toward modern types. Among the crustacea and molluscæ there was a decided

advance, but the most remarkable variety of forms was among the reptiles.

Huge reptiles swam in the water, walked on the land, or flew in the air. Some were small, many were larger than elephants, while others rivaled whales in size. There were huge vegetable feeders walking on the ground, one species of which, the Atlantosaurus, is believed to have been 100 feet in length, and more than 30 feet in height. No wonder poor bewildered Noah left them out of the ark ; or perhaps they were overlooked when he was planting trees in the ark—so the sloths could have food "after their kind,"—or identifying pairs of fresh water animalculæ with his microscope. The Jurassic contains the earliest known birds. They had teeth in their jaws—connecting them with the reptiles. Some had long lizard-like tails with a couple of feathers in each vertebra.

Still the mammals seem to have been only represented by a low type of marsupials. The Bellemnite, allied to the squid and cuttle-fish had an inkbag with which, like the squid, it sheltered itself from its enemies by ejecting an inky fluid. These inkbags have been found with the fossil ink (sepia) well enough preserved to be used for pigment.

The distinguishing feature of the Cretaceous period was, as its name implies,—White Chalk. There are extensive white chalk formations in England and northern France. The Cretaceous strata are very extensive in Europe, Asia, Africa and North America. White chalk is remarkably pure carbonate of lime, and the best is almost entirely composed of the shells of Globigerina, and other microscopic animals. The same kinds of organisms are found living, on the bottom of the North Atlantic Ocean. The microscopic appear-

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ance and chemical properties of the mud or ooze on the ocean bottom are substantially the same as the chalk, and when it is dried it makes a grayish white marking chalk. Thus we have a very ancient and general geological formation extended to the times in which we live,—for white chalk is now forming. The chalk deposits of England, Texas, etc., composed principally of Globigerina, as they are,—were formed when the areas they cover were part of a deep sea bottom. Besides, the present Atlantic chalk formation is continuous with the chalk of England, and Central Europe. In one sense we live in the Cretaceous period. If the records were complete there can be no doubt that all geological periods would be intimately connected. Unlike other animals and plants the chalk organisms changed very little in millions of years; their environments remaining substantially the same, and few competitors were encountered for their peculiar deep-sea existence. These facts are regarded as strengthening the evolution theory.

During the Cretaceous period reptilian life seems to have declined, and we find the earliest known true bony fishes, such as the salmon, pike, perch, herring and cod. An important advance was also made in plant life. There developed in that long period,—the California Sequois, (or Red Wood,) juniper, and species of alder, maple, oak, walnut, beech, poplar, dogwood, sassafras, and others, similar to, but not identical with their descendants of the present day.

There were toothed birds with vertebræ like those of fishes and extinct reptiles. They had thin slender jaws instead of beaks.

The Cenozoic or Tertiary era, or age of mammals, is subdivided into the Eocene, Miocene, and Pliocene periods. The geographical changes that took place, brought the

continents and oceans, to more closely resemble in position and contour, those now existing. The temperature as indicated by the character of the fossils, was higher than at present. The ocean during the Cretaceous period, had extended up the Mississippi valley to near the junction of the Ohio river, and covered the plains westward to the mountains. The continent was gradually elevated, until in the Tertiary period, while Florida and the lower Mississippi valley still remained under the sea, the central plains west of the Missouri, became the beds of extensive lakes. They continued for a great period of time, during which deep fossil-bearing deposits were formed in their basins. Large lava-fields, the outpourings of volcanoes and great fissures, were formed, extending over large portions of California, Nevada, Oregon, Washington, Idaho, and British Columbia.

During the Eocene and Miocene, the Sequois became almost identical with the big red-wood trees of California, and magnolias, elm, willow, chestnut, plum, etc., resembled those of the present time. Extensive deposits were formed of the almost clear silicious shells of microscopic uni-cellular plants,—the Diatoms, in some places like the Richmond, Va., deposit—thirty feet thick. Those familiar with the habits of living diatoms, can imagine the great length of time required for such deposits.

Reptiles had to retire before the more intelligent mammals; the brain became larger in proportion to the size of the animal. It was developed by use. The higher and more migratory animals, sharpened by the variety of their surroundings, developed faster than the lower invertebrates and molluscs. The mammals became numerous, and stood at the head during the Tertiary periods. Bees, ants, and butterflies came to the front rank of insect life. There were species of apes, monkeys,

deer, and the progenitors of the horse. The reptilian birds became extinct, and their descendants, water birds, and land birds, became numerous.

In the Pliocene period, the upward march continued as always before,—an unbroken steady movement. This general evolution can be best illustrated, perhaps, by taking a single example like the horse. Most animals, the original type,—have five toes. The horse has but one toe, with its nail strengthened and developed into a hoof. Now, the Eohippus of the Eocene period had four toes on the fore-foot, and three on the hind-foot, and the rest were rudimentary. The animal was as small as a fox. Later in the same period the Orohippus, its probable descendant had lost the rudimentary dew-claw. In the Mesohippus of the Miocene the fourth toe of the fore-foot had disappeared, and was represented by a splint. Then, still in the Miocene, we have the Miohippus with the said splint nearly gone; the side toes diminished, and the animal as large as a sheep. Its Lower Pliocene descendant, the Protohippus, was still nearer like a horse, had lost the useless splint entirely, the side toes did not touch the solid ground, and it was the size of an ass. In the later Pliocene the descendant of this animal, the Pliohippus, was nearly a horse, had only one hoof on each foot, the two side toes being represented by splints. In the next period came the true horse with splints shorter, and shape and size perfected along with the feet. This is the story of the "creation" of the horse (and the other animals and plants) according to geologists and according to nature and the facts; and it was done more than 6,000 or 600,000 years ago, and took more than 6 or 600,000 days, and was done by natural selection. The work by the same methods is still going on,—and the day of rest is not in sight.

The Quaternary period is the last main division of the geological record. Early in the period, two important events must be noted: the Glacial, or Ice Age, and the development of a variety of man, competent to invent weapons, by using which he gained supremacy over the other species of animals. The struggle to which we refer began with animals that became extinct before any written records were preserved. Up to very recent times the descendants of those primitive men have warred with similar, but improved, flint implements against each other, and against living species of the lower animals. Judging by the time taken for the known development of man, his comparatively high development so early in the Quaternary period, and his so general distribution in both hemispheres, at that early time, would indicate that he must have well bridged by evolution, any gap between himself and the man-like apes as early as the Pliocene period.

In the Tertiary period tropical animals had roamed the temperate zones, and the climate of Greenland as proved by the fossils, was then mild. The Quaternary was ushered in by the gradual elevation of the northern portions of Europe, Asia and North America, with a corresponding southerly subsidence. This change went on until the rising areas had attained an elevation of some 2,000 or 3,000 feet above the present level. Greenland is now covered with a sheet of ice 3,000 to 6,000 feet thick. Such a sheet was then gradually forming, increasing year by year in thickness and extent, until in summer and winter, for many thousands of years, the Earth was covered with such an ice-blanket down to about forty degrees north latitude. This vast field of ice was then, as is now the case with the ice-sheet of Greenland, moving at a slow and steady rate in a southerly direction. Such

glacial movements are now seen also in the Alps, and other mountains, moving slowly down and carrying with them frozen-in fragments of rock to be ground and rounded, and left stranded or in heaps as the surface of the ice melts, and the glacier retreats. Such evidences as are known to be left by the mountain glaciers were left behind by the great ice-sheet of the Glacial period. It retired as slowly and gradually as it came on. Sometimes it would remain about the same for years; at one period it again advanced, before finally returning to its present limits.

Along the southern limit of the ice-sheet, and along the margin of its second great advance, are traced lines of terminal moraines; hills composed of boulders, earth, gravel, stones of all sizes, and clay,—commonly called drift. This is composed of granite and other rock material foreign to the places where found, but belonging to well-known strata farther north. Many of the rocks were brought in the ice hundreds of miles, and sometimes across valleys over one thousand feet deep. This glacial drift, with its conspicuous boulders is scattered over hills and valleys, everywhere north of the forty degree limit, and is of varying depth—from 30 to 300 feet. The surface of the rocks, immediately underlying this accumulation of glacial detritis, are marked and striated north and south by angular stones, frozen in the bottom of the mass of moving ice. No such marks and no such boulders are found in low latitudes, unless caused by mountain glaciers, or where favored by local conditions.

The Glacial period was probably caused by the changes in the elevation of the land, the discharge of the Gulf Stream across the then sunken isthmus into the Pacific, the withdrawal of all considerable ocean currents from flowing into northern regions, the Earth being in that

part of its orbit farthest from the Sun in winter, and in addition to this, the orbit of the Earth had reached its maximum period of eccentricity. Mr. Croll, from the astronomical data above indicated, thinks the Glacial period began 240,000 years ago, and ended about 80,000 years ago. These figures are to be taken with considerable allowance for there are good reasons for thinking that the geographical causes were more potent than the astronomical.

When the cold period had reached its height, the elevated northern regions began to subside, and the downward movement continued, until vast tracts that are now dry land were under water and the ice gradually retreated. The descendants of arctic animals that had been driven south by the cold, returned to their northern homes, but traces of arctic vegetation still remain far south of their original home. During the period that has since elapsed the land has gradually changed to its present level ; but changes of level are yet constantly going on. For instance, Norway and Sweden are now rising at a steady rate that has been accurately measured.

There was a gradual passage from one geological period into another. It is impossible to tell where one ended, and another began ; indeed, it can be said that in fact all geological changes are embraced in one great period of incomprehensible duration. The changes and the evolution, produced by the same causes, are going on to-day, the same as ever.

The plants and invertebrate animals of the present time, differ but little from those of the Quaternary period. They changed their habitat with the changing climate, moving northward since the Glacial period. On the other hand the mammalian fauna is almost wholly changed. The remains of these extinct species are often

found in a good state of preservation. Specimens of the Mammoth were found frozen in the ice in Siberia,—preserved so perfectly, that dogs ate of their flesh. These animals were twice as large as the common elephant, and were covered with wool or hair. Many skeletons of the great Mastodon have been found in the United States,—in marshes where they had mired and died. One found in the edge of a swamp near Wayland, N. Y., had among the ribs a large quantity of chewed material, evidently the contents of the stomach. On being examined with a microscope, this material was found to consist principally of the foliage and twigs of coniferous trees. These animals were much larger than elephants, having been about thirteen feet high, and twenty-five feet long. There were at that time in America two species of elephants, horses, gigantic bisons, and beavers, bears, lions, etc.

If the frequency with which remains are found is a criterion from which to judge, the large mammalia must have been very numerous. It was the culminating period of mammalian quadrupeds.

For untold centuries there had been developing from among the anthropomorphous apes, an animal destined to play a remarkable and most important part in the struggle for existence. Forced by the necessities of his environments, and the superior strength of his enemies, to use all his wits to secure to himself and progeny safety and food,—constant use strengthened, and exceptionally developed his brain. Compelled to live in the tree-tops, his fore-feet became, by small gains, continued through a great length of time, hands. Necessity is the mother of invention. The great mammals of the Pliocene, and of the Quaternary periods were formidable competitors. Their supremacy seemed assured; but at

this crisis the ape-man made a great stride in advance, by which his position at the head was secured. He invented, and with his dextrous hands was able to construct, artificial weapons. The great quadrupeds, with their clumsy toes and lazy brains, were outmatched by the quick-witted, nimble-fingered little fellow.

There is conclusive evidence that man was contemporaneous with the extinct animals of the Quaternary period. Beneath river-loam, twenty to thirty feet thick, in terraces of the river Somme, at different levels, there have been found in the undisturbed gravel—unquestionable flint implements, associated with the bones of extinct species of the hippopotamus, elephant, rhinoceros, hyena, etc. At Biddenham, England, true flint implements were found in river-gravel with the bones of extinct species of the reindeer, cave-bear, mammoth, bison, rhinoceros, hippopotamus, etc. A true flint implement has been found in a rounded pebble.

In many caves in different countries human bones and tools have been found together with the bones of animals now extinct. In a cave at Neanderthal, a human skeleton was found, with large limb-bones, and very thick and low skull. At Engis, on the Neuse, with bones of extinct and living species, and beneath a crust of stalagmite, a rather well-shaped human skull was taken out. A similar specimen was found at Mentone, near Nice. In a cave in Belgium human bones were found with those of extinct Quaternary animals. These bones indicate that the men were of a low type;—bent knees and a semi-erect posture.

Beneath the stalagmite floor of Kent's Cavern, England, was found a bone harpoon-head of fine construction. A piece of reindeer-horn, with a picture of a mammoth etched upon it, was taken from a cave in

France. Flint tools have been found on the Pacific coast in river gravels with the remains of the mammoth and mastodon. They have been found in several of the states in glacial gravels; and have been found associated with bones of extinct animals in a number of places in different parts of the world. Man's work has not only been found in, at present, temperate zones associated with the bones of tropical animals, but also in the same localities associated with the remains of Arctic animals, and bearing evidence of his having lived and died in the localities where they were found.

Sir John Evans, incoming president of the British Association for the Advancement of Science, 1897, said: "We have good evidence that palæolithic man occupied Britain at a time when the configuration of the surface was entirely different from what it is at present; when the river valleys had not been cut down to anything like their existing depth, and when the fauna was of a different character from that of the present day; that the time was sufficient to permit the erosion of valleys miles in width, to a depth of 100 to 150 feet." He rightly refers to the time required as "transcending our powers of imagination" and as being "inconceivable ages."

The time required for the whole geological record of our planet as preserved in the terrestrial crust has been variously estimated, by many up in the hundreds of millions of years and by a few as low as scores of millions. The 7 mile gorge of Niagara, 600 to 1200 feet wide and 200 to 300 feet deep, cut by the river since the Glacial period, taking scores of thousands of years, is yet—only of recent date. The Great Canyon of the Colorado river, 300 miles long, and in places 6,000 feet deep, much of the depth in solid rock, was all cut out

IMPLEMENTS OF CHIPPED STONE. NORTH AMERICA.

STONE ARROW-HEADS, MODERN. CANADA.

by the erosive action of the river. At the same time the plateau above has been worn down by rain erosion leaving tall "buttes" standing. This work took time.

Rocks ground to sediment, deposited, raised and solidified, and the process many times repeated, and notwithstanding the gaps left by erosion, and the unknown quantities not in sight; that which is exposed to view, the 14 miles of thickness heretofore mentioned, took time and plenty of it. The formation of such deltas as those of the Nile and the Mississippi took time. It took a vast period for the beds composed of the diatoms or of the globigerina to accumulate. Vast periods were required for the lacustrine deposits, and for the coal beds, and peat beds, and beds of lignite, and coral reefs and islands—and the end is not in sight.

There is only one excuse for belittling the antiquity of this record, and that is,—the *bias* that sticks. We have inherited it, and nourished it, and have been baptized and saturated with it, at Sunday school and church. There is no sense in thinking that one generation can free itself from it. There is no merit in believing that which we have plain and reasonable evidence of; but the reward comes from believing the ancient and child-like theory, the miracle, the impossible; that takes *faith*, and that is what we are saved by. We were taught that the world and men were created "very good," and stayed so a few years, and that this was accomplished less than 6,000 years ago, and we are a little afraid to admit even to ourselves the full significance of the newly discovered facts. We cling to the old notions like an Asiatic to a wooden plow. We have changed plows, and have no further use for threshing floors, well-steps, flat worlds, star-lanterns, javelins, bows and arrows, sickles, and the like, but we cannot

shake loose the theological and chronological creations that belong to the same age and are on the same dead level.

Some timid souls have taken it upon themselves to deprecate, what they are pleased to call the attempts of some geologists to over-estimate the duration of the geological periods. We have never seen such attempts, on the contrary there has been universally, from the causes indicated, a tendency to adopt minimum estimates. Under the circumstances it is hardly possible to over-estimate. The present writer confesses to being conscious that he is still influenced by these early "causes," and, as the reader has probably noticed, either refrains from making estimates, or adopts the minimum figures. We do no violence to this superstition when we predict that the time is not far distant when it will be generally admitted among scientists, that men, the forefathers of the present race, although in a transitional state, were already the intellectual lords of the animal kingdom, hundreds of thousands of years ago.

## *CHAPTER XI.*

## THE ORIGIN OF SPECIES.

WHEN men first began to wonder how the objects around them, the solid ground, the seas, the trees, the Sun, the Moon and stars, the animals, themselves came to exist, they very naturally ascribed it all to their deified ancestry or mysterious invisible beings possessing the power to make all things. They themselves had made useful implements from wood and flint. Thus were the methods of the gods supposed to be allied to human methods,—Nature's ways being then unknown.

Through all the centuries, and up to very recently, mankind, with few exceptions, have believed that the different species of animals and plants were made from earth,—one week not 6,000 years ago, by special creative power. The species were believed to be fixed. When the science of geology began to gain a foothold, and it became evident that the fossil animals and plants were not the victims of a Noachian deluge, but that they had lived long before the historical or the mythological periods, a new explanation was looked for, one that would not antagonize the old creeds. So it was assumed that the creative power of the deity, had been exerted from time to time during the geological periods as occasion seemed to require. Men had inherited this creation disease, through such a long line of revered ancestry, that no remedy could do more than palliate.

Before the commencement of the present century the great mind of Goethe began to reject the special creation theory and grasp the true solution of the problem. He held that all parts of a flower are modified leaves; that skulls are modified vertebræ, and that plants and animals have been evolved from a few parent types. The new theory was dawning among advanced thinkers and workers like Erasmus Darwin, the grandfather of Charles Darwin, Kant, Buffon, Lamarck, Saint Hilaire and Oken.

In November, 1859, "*The Origin of Species by Means of Natural Selection, or the Preservation of Favored Races in the Struggle for Life*," by Charles Darwin, was published. The great work was supported by the accumulated and tabulated facts. It was attacked by an army of big and little theologians. They knew the weakness of their defences, and attempted to frighten and mislead with clamor.

Defenders like Wallace, Haeckel, Spencer, Huxley, Tyndall, Hooker, Lyell, Draper, Gray and Youmans came to the support of the unpaid truth. Such an avalanche of books, pamphlets, papers and tracts, all upon one subject, the world had never seen. Darwin stood unmoved upon the corner where the advancing thought of the world halted momentarily, and then,—filed to the *right*. The march has been steady and continuous in that direction ever since.

Defeated in their frantic attempt to destroy the Darwinian bridge, the hosts still suffering from the inroads of the creation microbe, are trying to prevent the completion of the approaches, and thus compel their followers to continue to flounder in the quagmire of superstition or to take to the woods. It is a forlorn hope, for the time is near, when the bridges, the highway, the temples and the truths of nature, with all their wealth of utility

and relief, will be free to all. Then men will cease to fear.

We have seen that the primitive notions of mankind regarding the stars, the Earth, the fossils, etc., were wrong, therefore their notions that living beings were miraculously created instead of being naturally produced, cannot be considered as authoritative. The operations of Nature show a continual succession of cause and effect, and for lack of observation, the operation of these natural causes and effects was not understood by the ancients. To those not conversant with the gradual changes of level of the Earth's crust during the later geological periods, with the formation of the mountains, seas, rivers, continents and islands, the miraculous explanation was the only one. The question of the origin of species, being more complex, was of course beyond their ken.

If the numerous varieties of dogs had been found wild, differing as greatly as they now do, would they have been classified by naturalists as belonging to one species? The same question is applicable to horses, cattle, sheep, swine, fowls, pigeons, and every animal that has been modified under domestication. There are great differences in size, color, hair, shape, habits and physical and mental capacity. The resemblance is only general, between the greyhound and the pug, the mastiff and the terrier, the race-horse and the cart-horse or the pony. Their dispositions have become just as decidedly dissimilar. In the care of stock, the shepherd dog has through years of selection, training and breeding for a special purpose, become in some respects almost as sagacious as his master. The race-horse and the greyhound have become slim, long in nose, neck and limbs, with hardened muscle, and all parts adapted through long continued slight changes to the purpose for which they are bred. The individual

variations which are noticeable in all species of animals and plants, have in the cases of domesticated animals and plants been seized upon and perpetuated by breeding and grafting, according to the interest or fancy of their owners. The reader will recall many such instances. I recollect of being delighted when a boy, at a flock of chickens that had been purchased from various sources, and embraced Brahmas, Bantams, Crested Polands, Dorkings, with five toes, Dominiques, and a breed without tails, and another with the feathers pointing toward their heads. Then there were pigs that shed their tails when a few weeks old.

If in variation under domestication, a process of selection where undesirable qualities are eliminated and desirable ones indefinitely retained, results in distinct varieties; then why not form species by the continuance of the same processes through an indefinite length of time. Geology, Archæology and History give all the time required, if natural selection is at all as efficient as human artificial selection.

Great as are the present differences among domestic pigeons they have all descended from a common stock, the rock-pigeon. The dogs could be traced back to a few allied wild progenitors, if the records were complete. The same holds true of the other improved breeds of animals and the improved varieties of fruits, ornamental trees, shrubs and flowers. The same original stock contained the potency, of producing either the Crab-apple or the Tallman sweet, under different conditions. The multiplication of wonderful varieties of roses and other ornamental flowers is looked upon as a matter of course. In garden vegetables remarkable improvements have been made by selection as well as in wheat and other cereals. For example take the Bras-

sica oleracea: there have been produced from it by selection the common cabbage with the leaves modified into a solid edible head; Brussels sprouts, the tender sprouts growing thickly around the stem; kale, with the tender leaves developed separately; kohl-rabi, or turnip-rooted cabbage, and the cauliflower, with the flowers forming a solid edible head. Then there are numerous sub-varieties of all these. We can form an idea from all this how the existing species of animals and plants have branched off from fewer ancestral forms; they in their turn having been derived from still fewer and simpler forms.

The great improvement of our domestic animals and plants is not due so much to special selections of very noticeable variations, as it is to the saving through heredity of slight, scarcely distinguishable variations by the general practice of selecting the best specimens to breed from, or the best wheat, corn, etc., for seed.

Most people who have had opportunities to live in the country, must have noticed individual variations among animals and plants in a state of nature. Boys who have gathered chestnuts or beechnuts know, that in the same grove hardly two trees will be exactly alike in growth or quality, and that the same is true of the fruit. One tree will yield small light-colored chestnuts, another large dark-colored ones. The burs on one particular tree almost always contain three perfect nuts each; on another, two perfect with a middle one false, and a third tree bears burs that contain one large nut, the side ones being false. Then, there are varieties of chestnuts in a state of nature, quite as distinct as are the varieties of cultivated plums. This feature is common among plants.

All living organisms are capable of adapting them-

selves, to a greater or less extent, to their conditions; and in their turn are modified by their surroundings. The organism acts upon its environments, and they upon it. The tendency of individual animals in a state of nature to vary and form varieties, is as marked, as is the same tendency in plants, and varieties sometimes occur so near the artificial dividing line between nearly allied species as to be hard to classify.

We have then the tendency to variation and adaptation in the state of nature; do we also have selection? Is there a natural selection, capable of preserving the best, as is the case under domestication, where the selection is largely made by man?

Two plants cannot grow in the same place, or prosper if too close together; if attempted, the stronger feeder, the one best adapted all around to the conditions, will survive and the other will dwindle. The one that succeeds will grow vigorous seeds, and give its progeny a better start in life. This principle applies to all animals as well as plants. If there were no competing animals, and rabbits for example were left to freely multiply and obtain food without restriction, in a short time they would cover the Earth. This is true in a large degree of all living things. But every plant has to struggle for its chance at the air, and its roots cross the roots of numerous others in the ground. Every animal finds its pasture encroached upon by many others. There are vastly more animals and plants produced than can by any possibility obtain food and survive to adult age. There is a continual struggle for existence. Those only survive that are best adapted to their conditions. Under this state of things it is evident that any variations, however slight, that are advantageous to the individual in the struggle, will be more likely to

secure the welfare of that individual and enable it to transmit the newly acquired quality to its descendants. The necessities arising from the severity of the struggle have caused the favorable variation to be selected and perpetuated. On the other hand unfavorable variations would in time be eliminated. Nature makes the selection directly—as surely as she does through the agency of man. So we have selection under domestication, and natural selection in a state of nature.

Take for illustration a period of more than usual climatic changes, say the Glacial period; those organisms that had reached too high a degree of differentiation in any one direction, and being, therefore, less capable of adapting themselves to the new conditions, would die out, while the more plastic and less specialized forms would survive. The distribution would be affected also, for Arctic animals and plants, already accustomed to the cold, would extend their pasturage to the south. Variations in the direction of heavier coats of fur, skill in burrowing, fishing, etc., would be retained; less improved forms would become extinct.

No very extreme variations are required to account for the differences that exist between species, on the principle of natural selection; in fact, a variation might be too great to prove an advantage, and be eliminated as a monstrosity. Only the small, useful modifications, corresponding with climatic and other changes, are perpetuated.

It may not be out of place to call attention to a few, out of the multitude of cases, where natural selection has been the means of producing important modifications. There are habits and peculiarities, that serve to conceal the possessor from its enemies or its prey. Such is the case with insects that are the color of the leaves,

bark, or flowers on which they feed. Their color protects them from being so readily seen by insectivorous birds. Those varieties possessing this mimicry in the highest degree were the favorites in the struggle for existence. The tree-frog finds his color useful in decoying his prey. The whippowil lays her two eggs among the leaves on the ground without any nest; the downy young birds are the color of the dead leaves, and it is difficult to tell the old bird from a knot or piece of dead wood. The down on some fruits is a protection against curculio, the beetle attacking smooth fruits in preference. This is like the protecting thorns and prickers of many species of plants. They are either modified limbs or vegetable hairs.

Leaves are metamorphosed in many useful ways. A potato is a leaf changed by being under the surface of the ground. Flowers are modified leaves.

Many kinds of flowers depend upon bees and some other insects, in no small degree, for the distribution of pollen grains to fertilize the female flowers. Natural selection has enabled them to attract bees by the nectar secreted and condensed near the base of the petals, and by their striking beauty. The pollen readily adheres to the hairy covering of the bees and is carried from flower to flower. The tongues or mouth parts of bees and butterflies are also modified by natural selection, to give them sufficient length to reach the nectar of their favorite flowers. So it comes to pass that changes in one or a few species may affect many others.

The Sarracenia, or Pitcher-plant of our bogs, attracts insects to its hollow tubular leaves, that are generally part full of water, in which the insects drown, decay, and help nourish the plant. Natural selection has modified the form of the leaves, the size of the openings,

and the coarse hairs in the throat of the leaves, pointing them downward so the greedy prisoners are less likely to make their escape. To verify this statement look in a convenient marsh for the Pitcher-plant and while there do not forget to search carefully among the thick plants in the bogs for the low-growing, delicate, little Drosera rotundifolia, or sundew. The small, round leaves, fringed with gland-pointed bristles, exude a sticky substance. When a mosquito or small fly alights, or you place a tiny bit of meat on the leaf, the tentacle-like bristles close in upon it and the glands proceed to digest it, and it is assimilated as food. Fed in this way the little plant has not much need for roots, therefore natural selection has been parsimonious in that direction. Transplant some of the best specimens for more careful study. The Dionæa, or Venus's Fly-trap, belongs to the same family of plants. The botanist will never deny the usefulness and truth of the theory of natural selection ; the old notion of special creation is entirely inadequate. To account for all the changing forms, special creations would be required every day in the year.

The sting of the bee is a modified ovipositor, become useful as a weapon. The mouth-parts of the female mosquito, the horse-fly, etc., as modified, are instruments admirably adapted to making a puncture, and enlarging it sufficiently to let the thinned blood pass freely. In the water beetles the posterior pair of legs show in different species a graded adaptability to use as propelling paddles.

The variations necessary for speed that we have noticed in race horse and grey-hound under domestication, have been produced in a state of nature by natural selection, among timid animals whose safety lies in

flight, like the deer and the antelope, and the wild horse. In the domestic animals selection by human agency becomes the finishing touch of natural selection. This is especially apparent in the case of the horse.

A potent factor in natural selection has been the choice of mates by animals when pairing; the successful competitor having to show superiority in strength, beauty, sagacity, color, courage, etc.; the qualities for which he or she was selected standing a better chance of being transmitted to posterity. Thus the sexual selection exercised by the females in many species of birds has led to wonderful beauty of plumage among the males. The peacock may be cited as an example. The superior size and strength of the males quite generally prevailing among the mammals is no doubt due to the same cause,—with fighting qualities instead of beauty the criterion.

Darwin, in discussing the divergence in character, and showing that "The greatest amount of life can be supported by great diversification of structure," says: "But as a general rule, the more diversified in structure the descendants of any one species can be rendered, the more places they will be enabled to seize on, and the more their modified progeny will be increased." This proposition carries with it less competition with similar forms, and seems to be self evident. Then, as a successful variety goes on diverging from its parent stock, its position becomes easier and better assured. Then, all that is necessary for it to eventually become a distinct species is the certainty of sufficient time. As we have demonstrated clearly enough, no one need have any fears of natural operations being stinted for time.

The process, then, can continue on indefinitely, individual variations forming varieties, favored varieties

forming species, the fittest species diverging into genera, and from genera to families and so on to orders.

We thus have arising from the primordial protoplasm two mighty trunks, the vegetable and animal, with branches and secondary branches, and smaller divisions, —like giant trees, extending down through the ages. Many branches have died out, leaving the living more vigorous. The places of the living species on these genealogical trees are at the ends of the living branches. There has been no break in the line of descent from the earliest to the present forms. The highest now living have lineally descended through innumerable generations from the simple organisms that were the only inhabitants of the Earth in earlier geological periods. In species as in individuals the fittest have survived, and those least fitted have perished. Only a few of the many early species are represented by living forms. Species weak in numbers, and with many competitors equally or better adapted to the prevailing conditions, had to die out. Hence we see that from the first there has been, as the geological record proves, a succession of constantly improving organisms; and we comprehend why it has been so.

If all the dry land should become partly submerged to the extent of converting it into marshes, it is evident that the direction of development would be changed, and the higher animals and plants would under natural selection, deteriorate to conform to the new conditions. There have been plenty of places from the start, unfitted for the higher organisms, and therefore voluntarily abandoned to lower forms. The infusorian is at home in a drop of stagnant water, and any considerable evolution of its structure would be detrimental, so it remains for millions of years an infusorian—if its environment remain un-

changed. This holds true to a certain extent with all organisms. It follows that we have living at the same time the higher organisms peculiar to recent times, and many of the lower types holding over from earlier periods. As long as there are places only fitted for the lower orders of animals and plants, they will be occupied by such, and little or no advance will be made among them. The competition from among higher forms remains at a minimum.

Again Darwin: "As buds (of a tree) give rise by growth to fresh buds, and those, if vigorous, branch out and overtop on all sides many a feebler branch, so by generation I believe it has been with the great Tree of Life, which fills with its dead and broken branches, the crust of the Earth, and covers the surface with its ever branching and beautiful ramifications."

Under the conditions arising from ceaseless and untiring change in everything pertaining to our planet, it happens that no two individuals are begotten under the same general conditions, nor, even if of the same parentage, from the same admixture of exactly the same sexual elements. When this fact is fully considered, it becomes at once evident that variation in the character of the offspring, must be the general rule. Still more light is shed upon the causes of variation and also of heredity, when we consider that the newly conceived organism is composed of particles of the actual substance of its parents; and that this substance has the attribute of increasing in size by the assimilation of nourishment, without losing its original peculiarities.

Organisms are modified to some extent by climate, food, associations, etc., during the plastic period of their lives.

Effort put forth by a highly developed animal leads to

action that strengthens the organs that are used the most. Conscious effort may therefore be one of the causes of development, but not a primary cause, for the effort itself is an effect, and may generally be traced back to an initiative cause or causes.

It is a matter of common knowledge that use strengthens, and disuse weakens, organs. The microscopist's eye that is used the most, if the work required of it is not excessive, becomes stronger than the other. The increase in size and strength of the right arm of a blacksmith is a case in point. This principle is familiar to those who use the bicycle, do manual labor, or train to develop muscle. There can be no doubt that the modifications brought about through effort, use and disuse, are transmitted to offspring. Disuse has weakened and diminished the wings of such birds as the ostrich and the Brahma fowls, and other large-bodied, small-winged, non-flying fowls, while their legs being used more have increased in size. Moles, habitually burrowing in the ground have little use for their eyes, consequently they have become almost blind and in some cases the eyes have become skinned over. To compensate, their noses are highly developed and sensitive to the touch, being in constant use to feel their way. The star-nosed species with developed nose-feelers is especially remarkable. Fishes living in dark caverns, having no use for eyes become blind, like those in the Mammoth Cave, Kentucky. They are not only blind but the eyes are under the skin. The presence of partly obliterated eyes proves that the fish were not designedly created blind, but that they have become so by modification through disuse. Besides, they are connected by gradations of structure with species having normal eyes.

Organs are sometimes developed through natural se-

lection partly at the expense of less useful adjacent ones. The increased use of the brain by the more highly civilized peoples, and the decreased use of teeth because of the food being more finely prepared, and requiring less mastication, has tended to produce better brain and poorer teeth. The part that is most used will receive the greater flow of blood, and therefore the most nourishment.

The flank-membrane of the squirrel is, in some species, more or less distended, and in the flying squirrel it is so greatly distended, as to unite their limbs and the base of their tails, so as to form an imperfect substitute for wings. They can sail to a considerable distance and so escape their enemies, secure food in otherwise inaccessible places, and avoid injury in case of accidental falls. The extreme of this remarkable kind of variation is reached in the hands and fingers of bats, and becomes more useful by reason of the character of their food.

In studying the probable origin of complex and highly differentiated organs, like the eye, we must trace them backward to simpler forms. We have in the infusoria eyes that are merely more delicate and sensitive spots. Bare nerves are sensitive to air-waves, heat, and if very delicate, doubtless to light. The simplest forms of eyes in the lowest living animals are not much if any more than ends of nerves shaded with pigment cells. The gradation from these to the eyes of the mammalia is tolerably complete, and with a perfect geological record would be quite so ; but, of course a structure as delicate as the eye could not be expected to be well preserved in a fossil state. However, in no other way are such delicate organs so well accounted for as they are by the theory of natural selection ; and it is done to the satisfaction of the naturalists best qualified to judge.

The dust that covers the wings and bodies of butter-

flies, moths, mosquitos, and some other insects, is seen under the microscope to be scales arranged in rows overlapping like shingles on a house. The scales are modifications of protuberances of the skin, and vary in shape, all the way from true cylindrical hairs to flat scales as wide as they are long. The scales of fishes are similar modifications of the skin. The hair of the higher animals is but a modification of the same kind. It answers for clothing, defense, and ornament. It is correlated with the nails and teeth. By natural selection all intermediate grades of hair are produced, from fine fur and wool to the defensive barbed quills of the hedgehog and the porcupine. In the birds may be seen true hairs, hairs with branches, and variations all the way to highly developed ornamental feathers. Many of these modifications have been brought about by selection under domestication.

When a person allows his thoughts to run in any certain direction a second time, he finds the movement easier than the first, and so on by repetition until a habit of thought is established, and the person thinks in a groove, as we might say. The first disturbance of the molecules of the brain cells form a memory record, and the subsequent impressions strengthen it until it assumes undue relative importance and the person becomes biassed or "cranky" in that direction. Such impressions may become stronger than those produced through the eye or ear by external objects; and when they do so, they may have as great or greater force with the individual than objective impressions, and thus cause the person to be subject to hallucinations. Or, falling short of hallucination, habits of thought may be established, and perpetuated by the laws of inheritance, the same as habits of action are transmitted. Habit is

then an important factor in natural selection. It is easy to fall into habits of thought or action, and still easier in the direction of inherited tendency. In this way habits are formed that possess all the force of instinct, and cannot be distinguished therefrom.

It will be remembered that bees, ants and other of the higher insects existed quite early in geological times, so they have had an enormous period in which to perfect beneficial habits, acquired little by little through natural selection. Tiny chunks of wisdom, scattered through the ages, have been aggregated into the perfection of the hexagonal cell of the honey bee, and its system of labor, so that little direct reasoning is now necessary in their communities. This is instinct which was once reason. Yet, experiments have shown that honey bees will vary their methods somewhat to meet new conditions; they have some reason as well as inherited skill. There are allied species of bees that construct more simple cells, and not always the perfect hexagon. We have here as everywhere, the gradation of structure showing the handiwork of natural selection; the opposite of special creation. The humble-bees make, as every country boy knows, irregular, rounded cells, and there are other species of bees that make cells intermediate in form between those of the humble-bees and the hive-bees.

We, ourselves, have instincts that we sometimes follow when reason would have been the better guide.

Some aphides secrete a sweet juice of which ants are very fond. Some species of ants keep and take care of these aphides for the purpose of having the juice, as men keep cows for their milk. They care for the eggs of the aphides, pasture the insects on neighboring plants, attend to their safety in times of danger, and in

return the aphides voluntarily yield the sweet juice when the ants require it. Their aphides are in every respect domestic animals. Some species of ants are so very highly "civilized" as to make long marches (for them), form in regular order, and fight fierce battles, and kill or make slaves of prisoners. Some use prisoners for domestic servants, not permitting them to go outside the hill. In time the ants held as servants become contented and faithful. The properties of protoplasm are made manifest in much the same way through ants as though men. Nature has given like results, or different results, according to the varying conditions through which each has passed from a common ancestry in the early days of our planet. The ants possibly look up to us big fellows as divine beings, creators of the great fields they have traversed, and the little Sun and Moon. Let us be just and kind to them, and if any among them shall be honestly mistaken, not cut off every chance for reform by visiting upon them a punishment that endureth forever. Let them be judged by their works and not by their beliefs. We must not expect them to be better than the beings they worship.

We see the same causes operating now that brought about the changes during the geological periods. Then as now, as a general rule, as species succeeded each other in time, they were higher in the scale of evolution. There is no gap between the past and the present ; they insensibly connect. The theory of descent with modifications explains in a natural way, and in accordance with generally recognized principles, the facts as known. Every new discovery made in the incomplete geological record, strengthens the Darwinian hypothesis, by adding another intermediate form to those already known. The origin of species by natural selection through descent, is

now believed in by workers in all branches of science. From the start of the first living form up to the present time, it is conceded by those competent to judge, that there has been no act of special creation among organic beings.

If anything more could be needed to strengthen this view, this question of Darwin's would be sufficient: "What can be more curious than that the hand of man, formed for grasping, that of a mole for digging, the leg of the horse, the paddle of the porpoise, and the wing of the bat, should include the same bones, in the same relative positions?"

The great similarity of all organic beings is noticeable throughout,—in chemical composition, and in susceptibility to changes in temperature and food. They are all, vegetable as well as animal, delicately balanced, and easily influenced by the slightest changes. The connection is close, and incompatible with the idea of special creation by a being possessing much versatility.

From the point of view of the believer in the duality of the Universe, and intelligent creative action in any form, the phenomena of life, the gain of the few at the expense of the many, the inexorable operations of nature, if performed by an all-powerful being would be unjust, and unworthy. How true and apt are the words of Darwin "When I view all beings not as special creations, but as the lineal descendants of some few beings, which lived long before the first bed of the Silurian system was deposited, they seem to me to become ennobled." As to our duty, he said, "Whoever is led to believe that species are mutable, will do good service by conscientiously expressing his conviction; for only thus can the load of prejudice by which this subject is overwhelmed be removed."

To some minds the strongest evidence in favor of natural selection, and against the special creation theory, is found in organs that have become rudimentary. Rudimentary organs that are not only useless, but actually detrimental, exist, and according to the idea of special creation of fixed species, must have been so created; an utter absurdity; whereas they are readily explained by natural selection,—as parts undergoing elimination through disuse; but having been at one period useful to the ancestors of the present species. Organs, like species, when of no further use, become degenerate, and finally extinct. The loss of old organs, or species, is the necessary consequence of the development of new ones. When new and vigorous shoots come on a tree,—old limbs are robbed of their nourishment, and die out. This is one of the necessary processes of evolution.

Almost every kind of plants or animals has rudimentary organs. Rudimentary eyes under the skin of animals who have no use for eyes, and the wings of birds that do not fly, were previously mentioned. Very many insects have rudimentary wings. This is especially the case with two-winged species of insects; they having descended from four-winged ones, and have lost or partly lost the hinder pair of wings. The halteres of the common flies, just back of the wings, are rudimentary wings. In the different species of the Diptera, a gradation in this modification may be traced. Only microscopic traces of the ancestral wings remain.

Darwin speaks of the presence of teeth, never to be used, in the jaws of fœtal whales, in the upper jaws of unborn calves, and in "the beaks of certain embryonic birds." These now disappear in the mature animal. Most of the higher animals have muscles that are not used. To this rule man is no exception. The muscles

that moved the ears of our ancestral apes in a lively manner, in us are present, but so feeble that few men can move their ears at all ;—some by great effort, can do so. As a rule, with only a few exceptions, the mammary glands of all male animals are rudimentary. The crescent shaped fold of skin in the corner of the eye is all that remains of a membrane that, in some animals can be stretched across the whole eyeball to protect it. Fishes now living, allied to those of the Silurian period from which we probably lineally descended, possess this membrane fully developed.

The great German naturalist, Haeckel, said in his *History of Creation*, speaking of superfluous rudimentary organs : "Another of them is the rudiment of the tail, which man possesses in his 3 to 5 tail vertebræ, and, which, in the human embryo, stands out prominently during the first two months of its development. It afterwards becomes completely hidden. The rudimentary little tail of man is an irrefutable proof of the fact that he is descended from tailed ancestors. In woman the tail is generally by one vertebra longer than in man. There still exist rudimentary muscles in the human tail which formerly moved it."

The vermiform-appendix, hanging from the cæcum, is a modification of the intestine in man and some of the higher apes and the wombat. It may still be of some use in secreting mucus to act as a lubricant to the ileo-cæcal valve, and for this reason has not been entirely obliterated by natural selection ; but in many cases it is a positive damage to the individual, causing the dangerous disease called appendicitis.

In birds, only the left ovary is developed and yields eggs ; the right is aborted. Where by reason of modifications of structure, useful in important respects, there

does not remain sufficient room for the usual pair of organs, one does the work and the other becomes rudimentary. This is also the case with the lungs of serpents ; their bodies being long and narrow there is not room for a pair of well-developed lungs.

The life history of each individual frog exhibits before our eyes a most wonderful metamorphosis performed in a short time. The parent generative cells develop into the ovum, and from the ovum comes the tadpole. It has a tail used for swimming, no legs, no lungs, breathes by gills like a fish, and is aquatic and herbivorous. Two pairs of legs begin to bud, the gills are gradually absorbed as the lung air-cells form, the tail atrophies, and is finally completely absorbed, and the young frog leaves the water—with four good legs, a lung-breathing animal. This is all accomplished in a few weeks in billions of individual instances in a perfectly natural way, without the miraculous creative interference of divine providence.

These changes that we observe in one individual required for the race whole geological periods to accomplish. The present frogs have developed from lower forms by the processes of natural selection,—passing through the stages the individual illustrates. The growth of the individual is typical of the development of the race.

One great object in writing this book will be accomplished, if it helps to lead the readers to consult the best standard works for more complete information on matters here necessarily only briefly considered. Another, and still greater object would be attained if the reader should go directly to the fountain head, Nature, to investigate and learn the truth for himself; first banishing from the mind all that is possible of the per-

versity of the bias common to us all through inheritance.

Haeckel, in his careful and thorough study of the calcarious sponges, found not only that all the species had a common origin in one ancestral form; but he found several forms that "have been regarded, not only as belonging to different species, but even to different genera, all growing out from a single 'stock' or 'cormus.'"

Another strong proof of the truth of the theory of descent is found in the distribution of animals and plants. They are found at present not as if distributed from any arbitrary center or place of creation, but on the contrary are found as they would be if descended from allied geological fauna and flora. Thus the past and the present are connected, the present distribution agreeing with the changes resulting from continental changes.

It might very reasonably be inferred that primitive life originated in the regions where the Earth's crust first cooled,—near the poles. That there was at a much later period a continent, now submerged, in the Pacific ocean, that had much to do with the development and distribution of plants and animals, including varieties of men, has been rendered probable by the researches of Alfred R. Wallace in the Malay Archipelago. An important part of the geological record, especially concerning the human race, may lie buried beneath the waters of that ocean.

In tracing backward the origin of civilization, from the west toward the East, from Europe to Egypt, from Egypt to Central Asia, and on to China, the extreme eastern limit may not have been reached. Some of the gaps in the geological records may have had the

same cause. However this may be, as a rule the types of the inhabitants during geological times continue in their different areas unless disturbed by great changes like those causing the Glacial period. Subject to whatever changes may be due to migration, the present species occupy the same areas where their ancestors lived and developed.

Migration to the extent of considerably modifying the character of the inhabitants of some districts has taken place, caused by changes in the level of the land, change of climate, and the necessity of seeking wider ranges for food. Unusually heavy winds and floods assisted in carrying winged and other seeds, birds, insects, and accidentally, larger animals to new localities. Birds are also active agents in carrying seeds. Ocean currents, icebergs, streams, and various other causes have assisted distribution.

The various tribes of animals are intimately connected by gradual transitions in structure and functions. There are gradations in size all the way from animalculæ 1–50,000th of an inch in diameter, to whales weighing scores of tons. All the characteristic features of tissue and structure are connected by intervening gradations with the principal types. Physically, man is connected with the amoeba by thousands of intermediate forms. The mental development is parallel with the physical. The brain of man is no exception to the general rule of evolution. There are all grades of development in the nervous system from undifferentiated sensitive protoplasm or sarcode, to nerves, ganglia, cephalic ganglia, and the brain proper.

The vertebrate animals begin with the Amphioxus, which has no brain; in lampreys there is a modification or division of the end of the spinal marrow, which,

in the fishes may first be recognized with certainty as a tiny brain with cerebellum and cerebrum. In the reptiles the structure is still further advanced, and in birds the cerebrum is more decidedly larger in proportion, and the entire brain more complex. In mammals there is still further increase in complexity, and in the relative size of cerebrum to cerebellum, and of the whole brain to the bulk of the animal; this organ reaching its climax in man. The skeleton and the circulatory and respiratory systems show similar gradations upward through all these classes of animal life.

In the vegetable kingdom connected gradations from the simple to the complex are everywhere to be observed. The bacterium and the oak are connected by an evolutionary chain. All organic beings are united in a continuous network. The continuity from the lowest to the highest is complete and unbroken. We are all necessary parts of the same great, natural system. Through natural selection the effete branches and ramifications have died out, and those best fitted for the unstable conditions of life survive through their lineal descendants. Success in the struggle for existence was, and is, the reward of adaptation. Without plasticity all would have become extinct, or been confined without improvement to areas where the conditions of life remain stable.

Fidelity to the truth requires that we must not ignore the fact, that with man as with the lower animals, mental as well as physical characteristics are transmissible to offspring; and therefore must necessarily have been inherited. Diseases of the lungs, liver, or of the mind; peculiarities, such as pride, ambition, fixed ideas and beliefs are subject to the laws of inheritance. It follows that mind and body are subject to the same

laws of natural development. The student cannot, in his inner consciousness, deny the truth of Haeckel's conclusion: "This distinctly and irrefragably shows that the soul of man, just as the soul of animals, is a purely mechanical activity, the sum of the molecular phenomena of motion in particles of the brain, and that it is transmitted by inheritance, together with its substratum, just as every other quality of the body is naturally transmitted by propagation."

Every physician understands that the processes of digestion and generation, and the susceptibility to remedial agents are substantially alike in the higher animals and man. There is little to distinguish man from the higher species of the lower animals in the number and location of the bones or muscles. The principal differences will be found in shape and size.

When we come to compare their minute structure, with the microscope, nearly all distinctive features are lost. In many species the blood corpuscles are distinguishable from those of man only by their size; and there are a few species where the difference is too small for measurement with the highest powers, and the finest and most accurate micrometers. The microscopic structure of the bones is equally close, as shown by very thin transverse and longitudinal sections. This is also true of the fibers of the muscles, and the still more minute fibrillæ of which each individual fiber is composed. Nerves and brain show the same similarity in their ultimate analysis. Using first-class instruments with the best illumination, I am unable to distinguish between the finer tissues of the several higher species of animals, including man. The structure of the eyes, the capillaries of the liver and lungs, the Malpighian tufts and uriniferous tubes of the kidneys, the glands of the alimentary

canal, the mucous membranes, the cells throughout, all proclaim the kinship of man and the higher animals.

To establish the truth of a theory it is not required that every little objection must be answered, especially when all the facts have not been discovered; but it must afford the best explanation of the known facts. This the theory of descent certainly and easily does. Enough, and more than enough has already been advanced in this chapter, supplementing as this theory does the nebular hypothesis ; but the crowning argument I have reserved for the last paragraphs.

Prof. Haeckel, in his *History of Creation*, compares with each other the embryos of a tortoise (at 4 weeks), a chick (at 4 days), a dog (at 4 weeks) and a man (at 4 weeks). In the earlier stages of development it was impossible to distinguish between the four. In the stages above indicated, the form and little stubs of limbs, no fingers or toes at this stage, were the same, and the brain very nearly. Everybody knows the gills of a fish and the gill-arches to which they are attached. Now, each of the embryos of course including that of man, showed unmistakably the three gill-arches. They are in the embryos of all vertebrates. They only remain in the mature animal in fishes. This is positive proof that man and the other vertebrates descended from and through some fish-like animal.

A tortoise (at 6 weeks), a chick (at 8 days), a dog (at 6 weeks), and a man (at 8 weeks) are also compared. The gill-arches have disappeared. The brains of the mammals differ from the other two, yet the brain of the dog is almost like that of the man. Excepting the chick they all have five toes, and all just alike including the fingers of man. The "missing link" that would-be facetious writers have had so much to say about was

also discovered. In all these eight specimens the tails were of about the same length and shape. So each and every individual human being, whether he be peasant or emperor, has passed through the stages of gill-breathers,—and tail-bearers.

In this—the growth of the individual through these changes in so short a time, is more wonderful than the slow and gradual development of the race through the same structural changes. The life of each man is the type of the life of the human race.

## *CHAPTER XII.*

## FROM ROCKS TO BOOKS.

PRE-HISTORIC TIMES, is the title usually given to the indefinite period of time connecting the testimony of the rocks with the testimony of written history, and covered by the science of Archæology. Archæologists attempt to supply the evidence lacking in the later geological periods, and in the time preceding authentic history. That this period was of great duration there is no longer room to doubt. It is divided into four great epochs: The Palæolithic period, where geology left animals now extinct living at the same time with primitive man, and the stone implements he made were not polished; the Neolithic period, or Polished Stone Age, where metals were not yet worked; the Bronze Age, in which cutting implements were made of bronze; and lastly, the Iron Age, when iron took the place of bronze except for ornament, and men began to leave written records.

The early, crude flint implements are found widely scattered in both hemispheres, and under conditions that prove the presence of man during the subsidence of the continental ice sheets of the Glacial period. When we consider the great numbers of flint implements that have been found, and how common are

IMPLEMENTS OF CHIPPED STONE. EUROPE.

IMPLEMENTS OF POLISHED STONE. EUROPE.

specimens of them among the people; and how small they are compared with the extensive territory over which they were lost in the chase or in conflict, so that probably where a million have been scattered, only a few have been found; it follows that the time included in the stone age must have been of great length, even assuming the population to have been dense. Judging by what is known of the aboriginal races there could not have been, generally speaking, a very dense population in the remote past.

Some little use had been made of copper from the Lake Superior region; but, in the main, the American Indians were in their stone age when Europeans began to colonize the Atlantic coast. Therefore the slow distribution of flints had been going on from the Glacial period, and probably from the Pliocene, and has continued until a very recent date.

With man as with the lower animals, some hardy, primitive types hold over and live contemporaneously with their more advanced brethren; protected from extermination by distance, deserts or seas.

During the earlier period, the Palæolithic, the workmanship was extremely crude. Many thousands of years were required in which to make a little advance. This, however, has been the experience of the world all along, until the new methods of Science obtained a foothold, and men began to look to the living present for inspiration.

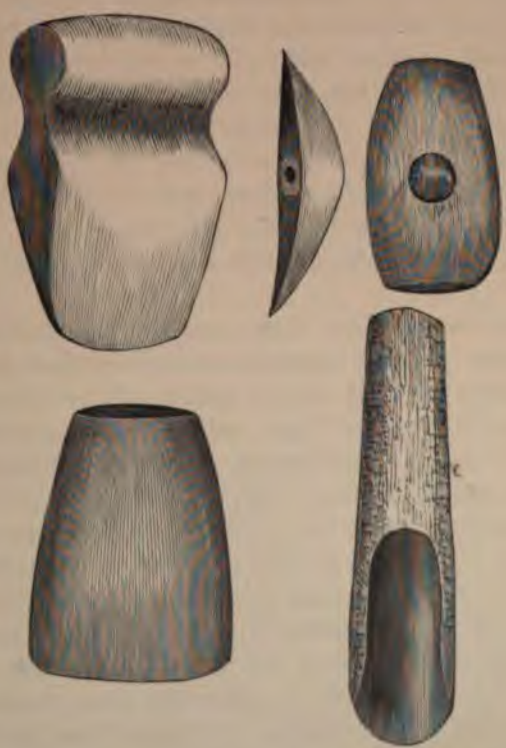
Some of the higher apes use clubs, and monkeys have been known to open boxes with sticks; but it is a great step from this level to the construction and use of even the crudest artificial tools. This advance was probably attained by degrees, and after the ancestors of the human race had habitually assumed the upright

attitude, even when not in the immediate presence of danger. We can imagine that wooden weapons and implements preceded those of stone. Trees felled by wind or lightning furnished broken limbs that required little shaping to become formidable war-clubs. Broken stones were useful to cut, and scrape, and smooth the jagged parts. Flint flakes being more useful were selected. It was a long ways but an even journey from the crude flint to the symmetrical arrow-head and the polished implement. It was the road along which the struggle for existence had led, and has since led, to the survival of the fittest. The laws of natural selection that led to the evolution of the constructive animal also governed in the evolution of the products of his hands and brain.

When the Palæolithic age began, only the favored few could own flint-flakes; wooden sticks were good enough for the many. The proud and arrogant possessor of a flint-flake was the lord of his day and generation, the forerunner of the modern aristocrat. How the last man of that age must have felt when he saw the dawn of the Neolithic age, and the coming man with the polished implements, teeth beads, and borrowed feathers. Nothing could be done; he had had his innings. Let his successors profit by his example.

His flint weapons, and occasionally some of his bones, are found by his descendants, mingled with the bones of the mastodon, the mammoth, the cave-bear, and a number of other animals which became extinct so long ago that no traditions of them were left to be recorded by the earliest historians.

The number of flint implements in public and private collections runs up to hundreds of thousands. During the stone ages, harpoons, needles, pins, etc., were made of bone, and often showed considerable skill. There



IMPLEMENTS OF POLISHED STONE. NORTH AMERICA.

are evidences of the division of labor, places being found where implements were extensively manufactured. Stone mortars, pe les, hammers, chisels, scrapers, gouges, axes, hatchets, arrow-heads, lance-heads, sinkers, etc., show all grades of workmanship.

These comparatively imperishable works enable us to form quite accurate opinions of the conditions of life in the infancy of the human race. They seem to have been very much the same as they are to-day among the more savage tribes. Trace backward the most highly civilized nations and we find a savage ancestry. We all laboriously ascended the same ladder and never missed a rung. To understand the past we have only to study its relics in connection with the daily lives of existing tribes.

As some evidence of the care with which scientists have conducted their searches reference may be made in this connection to the works of Sir Charles Lyell, Sir John Lubbock, Prof. Huxley, and the proceedings of the British and the American Associations for the Advancement of Science. The British Association has at different times appointed committees to make excavations, and thoroughly investigate certain caverns. Considerable money was appropriated, and the work was done with great care. A cave at Brixham showed flint-flakes mixed with the bones of numerous extinct species of animals, and appearing to be of the same antiquity. They were found at various depths; some of them in the gravel, eleven feet beneath the surface and covered with layers of cave-earth, with comminuted shale, and limestone breccia and a layer of stalagmite. The story of the cavern of Kent's Hole, and caves in Belgium, Sicily, France, etc., is the same. In one cave in England, Roman remains that are

known to antedate our era were found only slightly coated with stalagmite, while flint implements were found beneath an undisturbed deep layer of the same substance. There were strong indications that the deposition of stalagmite had been continuous and at about the same rate. Perhaps the most remarkable cave-finds are the sketches on bone or stone, of fish, reindeer, ibex, horse, mammoth and man.

The oldest human skulls and bones found in caves show that more than one race of men lived at an early period in Europe. Some of the skulls show, according to Prof. Huxley, "ape-like characters." It will not be considered far out of the way to assign to the cave-men a position about half-way both in time and development between the first men and the average of the present inhabitants. The more the subject is studied the more convincing becomes the evidence of the great antiquity of man. Crude flint implements found in the highest, and therefore oldest terraces in river valleys, prove that men hunted and fished along the rivers before the valleys were excavated by the water, but even then men were considerably advanced and widely distributed. Any so-called sacred, mythical, traditionary, or poetical chronology is pitifully inadequate.

The first metal that was very much used to take the place of stone in the making of implements was copper. At first it was wrought by beating into the desired shapes. It does not appear that the American Indians had acquired the art of casting it. It is said to have been used in China 2,000 years, B. C., and in India at probably a later period.

Primitive man has left behind him many evidences of his use of fire. In using this agent he had very early gained a great advantage over all other animals. Many

accidents must have occurred bringing under his notice the melting of copper. The addition of a little tin to the copper followed and bronze instruments were cast. This was an advance of far reaching importance. The tribes which remained ignorant of the use of the new metal compound were left behind in intellectual and material development. Of the alloy were made, Celts, swords, knives, pins, rings, bracelets, fish-hooks, sickles, saws, needles, buttons, arrow-heads, lance-heads, awls, rivets, chisels, etc. In the course of time much skill was shown in the construction and ornamentation of bronze implements, and regular foundries were established. Improvements were made in land, as well as lake and underground dwellings. Better boats were built, and commerce, "the civilizer of nations," received a new impulse.

There is no evidence from any quarter of the globe tending in the least to prove that the first men were perfect in any respect, and have fallen. Every investigated cave or lake dwelling, every tomb or mound, every implement, every trace of primitive man prove the contrary. There is not to be found a continent or large island, that does not furnish proof that its inhabitants have passed through the usual course of evolution from men without artificial tools, in a condition of savagery upward to the crude stone age, and still higher according to their capacities and opportunities.

Travelers have made us acquainted with a number of tribes, in recent years, that were in their stone age period, and some few that were below it, but struggling toward it. This gives the student excellent opportunities to judge of the early stages of development of the physical, intellectual, moral, inventive, religious, and other traits and qualities of our own ancestry. The con-

ditions existing among savage tribes when first discovered by more civilized men, were, with comparatively unimportant variations, characteristic of our own progenitors at some more or less remote period.

In this way much light can be thrown upon the early history of the human race.

The inhabitants of the Andaman Islands are thought by some to be the most primitive of the human race. Their huts have roofs of bamboo, or palm-leaves; the sides are left open. They hollow out logs, making of them dug-out canoes. At first they used bone tips for their arrows, harpoons and spears. They have no pottery, but use shells to hold water. They are skillful fishers, using nets and harpoons. They wear no clothes, count only up to two, and have no religion, nor belief in a supreme being, or in a future state of existence, and keep no domestic animals. The widow wears the skull of her dead husband suspended from her neck by a cord, using it for a trinket box. The other relations are content with a bone apiece. This custom ties them to the dead past—and serves one purpose of a religion; is in fact a germ from which the reverence for gods, saints, angels, authorities, and the past, in the modern religions has evolved.

The Hottentots had no religion, unless, indeed, certain ecstatic dances might be so called.

Some of the tribes of Australians had scarcely any huts, and ate putrid meat, grubs, snakes or anything a starved dog would eat. They use fire in hollowing out tree-trunks for canoes. Instead of canoes they sometimes used logs of wood sitting astride of them and paddling them with pieces of bark. They had on pottery and carried water in skins. Some had stone hammers, hatchets, and knives and splinters of flint, and used

sticks and boomerangs instead of bows and arrows, of which they were ignorant. Like many other savages they obtained fire by rubbing two pieces of wood together. They could not count above four, and their religion was very primitive, consisting of fear of the dark and of mysterious evil beings; and faith in witchcraft.

The Fuegians have arrows and javelins pointed with bone or stone and also slings and wooden clubs for weapons. Wallis relates that he saw a native take a live fish, kill it by biting near the gills, and then proceed to eat it, "beginning with the head, and going on to the tail, without rejecting either the bones, fins, scales, or entrails." They ate prisoners taken in war, and also the oldest women of their own tribes. Women are customarily illtreated by savages, and have about the same chance as dogs. Some of the Fuegians believe that there is a powerful being that lives in the woods. They carry their dead into the woods and cover them with boughs and old chunks of wood. They had no religious worship. Numerous savage tribes can be mentioned that had no belief in a supreme being, or, in the immortality of the soul, or in any form of religion; unless a belief in witchcraft and mysterious evil beings may be so regarded.

The Fijians believed, as stated by Lubbock, that "as they die, such will be their condition in the next world." This somewhat advanced belief in immortality caused the young people to kindly kill or bury alive their parents, so that they might start out younger and better able to travel the difficult road to heaven. Their faith was so strong that even the victims went cheerfully, and even joyfully, to their own funerals. There were no old people left in that section of "this vale of tears." Yet,

these people, who were constant eaters of human flesh abstained from eating their parents; but, perhaps, not so much from piety, or a sense of filial love, and duty, as from the fact that there were plenty to be had who were younger and more toothsome. Measured by the standard of faith, and the works naturally following it, the world has seen no people who would stand higher than these simple islanders; not even those who like Abraham, of old, were ready to slaughter their own sons.

Savages may show very good judgment in most things, may be able to send the arrow or the boomerang straight to the mark, or pick out and eat the best human joints themselves and leave the poorest to the women; but we owe them no apology when we value reason above faith, and accept Science and reject superstition. Another result of their belief in a future state of existence was that when a chief died, wives and slaves were killed and buried with his body so that they could go with him on his journey to heaven.

The native New Zealanders were a warlike race and fortified their villages with palisades and ditches, and as is ever the case, their gods were just as warlike, but a little more powerful than themselves. Their idea of heaven was that it was a place of continual feasting and fighting, where "they would be victorious, and have plenty of fish and sweet potatoes." Their principal god was a cannibal like themselves and they offered him human and other animal sacrifices. The smell of cooking flesh was a "sweet savor" to him. Sacrificial worship was practiced by many peoples of the earlier times, as every Bible student is aware. The New Zealanders had another strange notion,—the belief that when they ate the bodies of their enemies they acquired

their souls also. For the sake of gaining their wisdom they would devour the tough and otherwise undesirable bodies of old chiefs killed or taken in battle.

The most advanced people yet in their stone age were the Society Islanders. They had reached in very many respects a condition closely approaching civilization. They had plenty of good boats, carried on commerce, made excellent cordage, and cloth, and baskets, and kept hogs, dogs and poultry. With their general advance their religion had also become superior to that of other tribes and islanders, but was still a drag in the rear of their progress, as has been the case with every nation from the first. They sacrificed to their gods, and sometimes "offered up" human beings, and they believed in a first-class heaven for the chiefs and the "superior classes," and a sort of second-class heaven, or first-class hell for the common people. This plan of salvation was simple, and so natural that a trace of it may yet be found in more than one system of religion.

Some tribes of the North American Indians had no religion; no belief in a supreme being or a hereafter, while others believed in the "Great Spirit," and expected to live hereafter as they did in life, by hunting and fishing in the "happy hunting grounds." The arms of the deceased are buried with him.

The Esquimaux had no religion and were morally superior to average savages; they were honest and trustworthy.

Some Patagonian tribes had horses, and these tribes in addition to burying the arms of the deceased with his skeleton, and raising a cairn of stones over his grave, placed around it several dead horses supported in a standing position by props. According to Homer, at the burning and burial of Patroclus, horses and dogs,

and twelve captured Trojans, were killed and burned. The idea seemed to be that horses, dogs, and even weapons had souls or shadows that would be useful to the deceased warriors on their journey.

Sir John Lubbock after a careful examination of the evidence arrives at the conclusion that "those who assert that even the lowest savages believe in a Supreme Deity, affirm that which is entirely contrary to the evidence." Among those who do not believe in a god or gods may be mentioned the Indians of the Upper Amazon, the Samoans, the Aru Islanders, the Abipones, the Hottentots, the Kaffirs and the Bushmen. The tribes that praised their deities when their affairs were prosperous, and blamed them when things went wrong, or put up "scarce-crows to frighten away their deity," or blamed him for their toothache, or prayed to him to stop the ravages of grasshoppers, (see the prayer and grasshopper proclamation issued a few years ago by the governor of a western state,) were nearly in the same class in many respects.

The savage, like the primitive man, was continually and habitually alert, expecting to be attacked by enemies or dangerous animals; asleep, they were the subject of his dreams. Fear was always present. He was often unable to distinguish between subjective and objective impressions. It was but a step farther to a belief in invisible beings that possessed some mysterious influence for good or evil.

Stones have been used from very early times to mark boundaries and graves, and as memorials of places and events. They may be rough or hewn, plain or inscribed, single or in heaps, or in elaborately built pyramids. Heaps or mounds of earth were also largely used for the same purposes. Both earth and stones have been

extensively used in fortifications, and stone and brick for building dwellings and temples. In almost all parts of the world such evidences of the existence and condition of pre-historic men are common. In the Bible frequent reference is made to heaps of stones and stone pillars being erected as witnesses to notable events.

Among the most generally known of the pre-historic ruins is Stonehenge, a collection of huge stones on Salisbury plain, Wiltshire, England. There are 140 stones, weighing from 10 to 70 tons each, and they were originally arranged to form two ovals within two circles, with a bank of earth 15 feet high and 1,010 feet in circumference surrounding the structure. The stones, though weather-worn, still show the sharp angles of the tenons and mortises by which they were joined; the stones were roughly hewn. In the center of the work is a flat stone slab, 15 feet long, which is supposed to have been the altar. There are some 300 burial mounds within sight, scattered over the plain. Many of them have been opened and found to contain partly cremated human bones, fragments of pottery, and some of them bronze implements. The larger stones were doubtless obtained in the neighborhood of the temple. When this temple was erected is unknown; but there are good reasons for the opinion that it was in ruins at the time of the Roman invasion, 55 years B. C. There has been much discussion over this point, and various periods from 10,000 to 50,000 years ago have been supported by different authorities, but the evidence is by no means sufficient to justify any conclusion other than that it dates from a very remote antiquity. There are in this day modernized Stonehenges with stately steeples, in every hamlet and at the cross-roads, where much of life, liberty, progress and humanity are sacrificed.

At Abury, in Wiltshire, England, was a similar, but probably still more ancient temple, that in some ways surpassed Stonehenge. The outer ditch and bank enclosed 28½ acres. Inside of this was a circle made originally of 650 large unhewn stones. There were two small circles made of smaller stones inside the large circle. From the ruins of this temple two winding avenues of stones start and diverge in a serpentine form; one ending in a small stone circle. Midway between the ends of these avenues rises an artificial mound 130 feet in height, called Silsbury Hill. That this hill existed before the Roman conquest is proved by the fact that the builders of a Roman road changed from a straight line to avoid the hill. Of the people who constructed this wonderful work, or the period in which they flourished nothing is known; but there is reason to believe that the Phœnicians extended their commercial voyages as far to the north as Britain, and their civilization may have been a factor in so great a work. This idea is however of little value, for the ruins in question may have been ancient at that time. The ancestors of those who speak the English language were in their stone age when they made the temple, as the character of the work indicates.

Many monuments to the dead, consisted of a single unhewn or roughly hewn stone set upright, many others of heaps of stones, and others of stones placed in circles. The sepulchral circles vary greatly in size as do their component stones. Perhaps the most remarkable of these works is at Carnac, in Brittany. It consists of eleven rows of stones of different sizes up to 22 feet high. These rows of monumental stones originally extended several miles. The stones are unhewn and are therefore probably set by men unacquainted with metallic im-

*Monument at Carnac.*

plements. There are tribes in Asia that at the present day have the custom of using stones and stone circles for monuments. By putting two long poles under a heavy stone with numerous small cross poles for the men to take hold of, several hundreds of men move stones weighing several tons. Men enough, in this primitive manner, could in time construct extensive works. Rough hewing and mortising could be done with flint tools.

Dolmens, or table stones, flat stones supported by two or more others, are of frequent occurrence. Often the supporting stones are also flat and form the sides of a sort of box, or tomb, or table. Formerly they were held to be old altars for sacrifices. Now they are generally thought to be sepulchers. An opening was left through which offerings could be put in, or the spirit could escape.

The Indians made some use of copper from the Lake Superior region, but there are excavations more ancient of great extent, and twenty or thirty feet deep, proving that prior to their time the mines were worked by a more highly civilized people. Trees hundreds of years old, as shown by their annual rings, have grown on the dirt thrown out. Great numbers of tools were found, and a mass of copper weighing six tons lay as it had been detached by the unkown miners.

This ancient race was well advanced in the potter's art, and many fine specimens have been found in the numerous mounds scattered through the valleys of the Great Lakes and the Mississippi. Bowls of pipes were ornamented with accurate representations of the principal animals and birds of the region. There were shell-beads and copper-bracelets. The scarcity of weapons, and the final migration of the race southward, or

extermination, shows them to have been a peaceful people. When, and from whence the Mound Builders came is yet unknown.

We know that they were compelled to build defensive earthworks, and that their fortifications displayed considerable skill. The fortifications generally occupy strong natural positions, near the summit of steep hills, and consist of an embankment, and usually an exterior ditch. The question of water supply for the garrison was not overlooked, and gateways and approaches were well protected by interior, and sometimes exterior embankments. Fort Hill, Highland County, Ohio, has a line of circumvallation nearly four miles in extent, and from ten to twenty feet in height. Fortified Hill, Butler County, Ohio, and the Bourneville works in Ross County, are among the fortifications worthy of special mention.

Another class of works associated with the fortifications and mounds, are supposed to have had their origin in religious beliefs and ceremonies. They are found on plains instead of hills, and the ditches are inside instead of outside the embankments. They are of more regular outline, forming perfect circles, squares, octagons and other geometrical figures. A work of this kind at Newark, Ohio, covers an area of four square miles, with embankments from two to twenty feet in height, and it includes a large octagon, and a square, two large and a number of small circles, parallel walls, etc. In another at Chillicothe, Ohio, a large circle was united by a short passage-way, to an octagon of about the same size. At each angle of the octagon, an opening was protected by a mound on the inside.

Mounds of earth and stone, of various sizes and regular shapes are numerous. Such a mound in Illinois opposite the city of St. Louis was 700 feet long, 500 feet

broad, and 90 feet high, and contained about 20,000,000 cubit feet. Most of these mounds are probably sepulchral, and evidences of burial have been found in many of them. Others that have a flat space on top, avenues or means of ascent, like terraced pyramidal structures, were used as temples, or sites of temples or dwellings, for the rulers, and for points of observation; but their principal use was as temples. The temples were built of wood or bark, on top of the pyramids, and were reached by winding paths. They were rude structures that reached a higher development in Mexico and Central America. Their resemblance to temples and structures of the old world does not imply that they were derived from them, but does prove that humanity everywhere passed upward along substantially the same lines of development. This class of mounds are more numerous toward the south, and bear more resemblance to ancient Mexican works.

The Mound Builders not only made accurate representations of animals on stone and pottery, but in thousands of instances they left examples of their art in the form of animal mounds. These are most numerous in Wisconsin and Iowa. They are from one to six feet high, and represent men, buffaloes, bears, elks, otters, wolves, raccoons, lizards, turtles, alligators, frogs, birds, etc. They vary in length from less than one hundred up to several hundred feet. A serpent-shaped mound in Adams County, Ohio, is over 1,000 feet in length and five feet high, gracefully curved, tail coiled, and with open mouth, in the act of swallowing or ejecting an oval figure, formed also of an embankment of earth. Whatever it was intended to signify, it represents very well the oriental cosmological idea of the serpent and the egg. It seems to me probable that the

serpent was regarded as a sacred emblem, and that the Mound Builders were in a state of zoolatry, or animal worship. This idea would account for the immense amount of time and labor expended in making the huge animal mounds. There are some indications that the Sun and Moon were included among their deities. There is much evidence tending to show that unlike the majority of their Indian successors they were an agricultural people, with a dense and widely spread population.

Among the pre-historic ruins of Mexico are pyramids built of cut stone, square, rising in stages, and level at the top. The pyramid of Cholula, as measured by Humboldt was 160 feet high and 1,400 feet square at the base, covering an area of 45 acres.

At the time of the Spanish conquest, time had effaced all knowledge of the times when the ancient pyramids, temples and cities then in ruins, had been built.

Extensive ruins are found in Central America, with temples massively built and ornamented with richly carved figures. In Peru are similar ruins, temples, aqueducts, bridges, and paved roads hundreds of miles in length, and passing along mountain sides where the difficulty of construction was enormous.

The great temple of the Sun, at Cuzco was attended by 4,000 priests. There were many temples, but little means of defence against rapacious and skillful enemies. On the shores of Lake Titicaca were wonderful works whose origin was lost in antiquity. There are rows of great stones, some rough and some hewn, foundations, mouldings, cornices, doorways carved from single blocks of stone; ornamental carvings, and a terraced earth mound 650 feet long, 450 feet wide, and still remaining 50 feet high. There are stones of hard trachyte cut

*Wringcheese, near Liskeard, Cornwall.*

n a manner unsurpassed by any stone workers. Some dressed stones are twenty-five and one-half feet long, fourteen feet broad and six and one-half feet thick. Near Truxillo there are the ruins of the ancient capital city of the Chimus, covering 20 square miles; ruins of every kind, dwellings, temples, furnaces, prisons, and shops. One of the pyramidal temples is 812 feet long, 470 feet wide and 150 feet in height.

It is impossible to give an idea of the antiquity or the splendor of the Peruvian civilization that preceded the Spanish conquest; but it perished miserably when attacked by a handful of more warlike, but, in many respects, less enlightened men. The Peruvian Sun-worshipers were powerless before the followers of the cross,—the unscrupulous users of gunpowder, and insatiable seekers after gold.

The great pyramids of America had a greater area at the base than those of Egypt, but were not so high. They were easy of ascent, and used for a different purpose; those of Egypt being used for tombs and those of America for purposes of worship.

Every year the Nile overflows and spreads a thin layer of mud over the adjacent plains, and builds its delta a little farther out into the sea. The number of inches of mud that has accumulated during the historical period has been ascertained with reasonable precision. It has been burying the foundations of great structures at a steady rate, so the deposit per century can be relied upon as a basis for estimates. The total depth of the Nile deposit has been found by digging; and ancient Egyptian relics have been taken from the bottom, next to the undisturbed strata. Without allowing for the deposit being more compact by pressure as we descend, the time required for the work is nearly

12,000 years. This estimate agrees very well with what the historian, Herodotus, learned when in Egypt. Those who have no "accepted" chronology to bolster up will see no good reason to question the opinion that Egypt has been an inhabited country for at least twelve or fifteen thousand years, and that it was a prosperous nation, well advanced in the arts, at least five thousand years before the Christian Era.

The pyramids of Egypt are the monuments and tombs of kings, are found in a necropolis, and contain sarcophagi and mummies. The largest one covers an area of about 13 acres and contained 89,000,000 cubic feet. Its height was 479 feet and the length of its sides at the base 764 feet. In one of the sepulchral chambers near the center of the pyramid was found a sarcophagus too large to have been introduced through the entrance, therefore it must have been put in place before the room was finished. It contained the mummy of a king, richly decorated. There are numerous other pyramids built on the same general plan. To quarry the thousands of huge stones, hew them, transport them from a great distance, and raise them into place, required an amount of time, labor, and a degree of mechanical skill calculated to discredit the theory that mankind had been recently created. It required a long time for that branch of the human family to develop from the first stage of making artificial tools or beginning to use a few words, up to the construction of these surprising works. The most skillful modern builder would hesitate to undertake the job of duplicating these mighty structures.

The great sphinx is located near the great pyramid. The length of the body is 146 feet, and it is 36 feet across the shoulders. The head is 28 feet from the top

*Cromleh at Plas Newydd in Anglesey.*

to the chin. A small temple was built between the paws. The temple and paws are of solid masonry, but the rest of the sphinx is made of one piece of stone; a hole drilled 27 feet deep into one of the shoulders proved it. Smaller figures of the same kind, the head of a man on the body of a lion, were used along the approaches to the temple. Plutarch said they were placed before the temples as types of the mysterious nature of the deity.

The obelisks were hewn from single stones, and the large ones, 100 feet high, and weighing 400 tons, had to be transported in some instances 800 miles from the quarries to the places where they were to be erected. With any means at the command of the Egyptians this process must have required a number of years to accomplish. These wonderful shafts were probably used as monuments to perpetuate the fame of the great and powerful.

The ancient cities of Memphis and Thebes attest by their magnitude and the grandeur of their ruins the advanced state of the early Egyptian civilization.

At Elephanta, a small island of India, is a cave temple of unknown antiquity, 123 feet in breadth and 130 feet long, with many well executed sculptures. At Ellora are much greater cave temples, excavated in a hill of granite and basalt. The sculptured excavations are over a mile in length. The temple of Siva is 185 feet by 401 feet. There are many colossal figures; and the whole work rivals the pyramids in the amount of labor required.

The Egyptians carefully embalmed their dead to preserve the bodies as long as possible for the souls to again inhabit on their return. Their ambition to shine in the future was greater than that of any other people because

of the peculiarity of their religious belief. Their works were therefore made as massive and imperishable as possible, that they also might endure to the glorious coming time when the body would be resurrected and re-united with the soul. We, therefore, must consider the pyramids, obelisks, etc., as having been constructed for monumental and religious, rather than for astronomical or other scientific purposes.

In Italy and Greece, in Palestine and Syria, in Egypt and India, in Arabia and Peru the ruined cities and temples of once prosperous nations lost in antiquity, are found; but there are also found the stone implements of the primitive inhabitants of the countries. Compared with their times the builders of the pyramids were modern. The great works, though remote, were thousands of years later than the cruder work of the same varieties of men. Therefore, instead of the fall of man from a state of perfection, we have, in fact, the ascent, taken as a whole, of man from a state of savagery. It is simply a continuation of the evolution of geological times in accordance with the doctrine of descent.

Savage tribes have very few words in their language. Languages are of slow growth, and words are added only as necessity requires. Primitive man had become widely distributed, and the several varieties of men were distinctly branched off before anything that could be called human language had evolved. Means of communication through signs and inarticulate sounds as used by the lower animals were sufficient for their needs at first. Their language grew with the growth of experience and knowledge. All that men have attained has been slowly evolved with themselves. Their languages were no exception to the rule.

With the savage, everything begins small and simple

as with the child, and improves by the slow evolutionary process. For example take the plow. At first men used their hands to mellow and mix the ground, then ordinary sticks, then flattened sticks, then crude wooden spades, then a forked limb drawn as a plow, then improved wooden plows, then bronze tools, then various grades of iron plows and so on to the latest patterns of steel and steam plows. Those we now have will be improved; the first are never the best. In the pre-historic age the more advanced nations though well acquainted with a few useful things were behind the later centuries in nearly all important points.

There were times when the gain of centuries was lost by the inroads of barbarous and ambitious enemies, the zeal of fanatics, or the enervation of wealth. Such checks were only temporary. That which was lost in one direction was often gained in another. Nations have their life-history the same as do their individual units; their periods of childhood, youth, maturity, decline and death. The declining nation, like the dying limb of a tree, was often succeeded by one stronger, better and more vigorous. Thus, taken as a whole, the progress of humanity was secure.

There was a great advance made by the ancestors of the Caucasian race in religion, the arts, agriculture, commerce, etc., before books were written. Much valuable teaching was done orally. Records of events for the information of their posterity were not altogether left to the uncertainty and general unreliability of tradition. Heaps of stones and plain monuments were not much better, but they were followed by statuary and pictures, and in the course of time by picture writing. This led naturally to the use of cuneiform alphabetical characters and crude and pompous records were engrav-

ed on stones, monuments and buildings. As the centuries rolled away, stone and brick tablets became more common in the great cities of Western Asia and Egypt. It was a short step to the use of parchment and the invention of the art of writing. Before that time historians and poets, for instance Homer, went about repeating their productions to interested hearers. The mental task of composing and thoroughly memorizing must have been severe. The works could only be left for the next succeeding generation, through the trained memory of the younger men. It is no wonder that so little of value, of the literature of that period, has been handed down to us.

If the same differences were found among any of the lower animals that exist between the Caucasians and the Africans they would unquestionably be classed as distinct species, unless, indeed some lame creed stood in the way of acknowledging the truth. According to the old belief in the stability of species, each ought to have been assigned a separate origin. With the fact of the truth of the theory of descent through adaptation and selection fully established, all the species or varieties of men may be considered as derived from a common stock. Some one species of ape had become more human than any other. This assumption leaves the matter in doubt, for varieties arising from this family of anthropoid apes went out from the ancestral home at a time when they might not have been properly classed as human. As we have seen, some existing tribes are scarcely entitled to the appellation. There is a greater gap between the hightest man, a Darwin, a Huxley, or a Haeckel, and the native Australian, than there is between the lowest savage and the highest ape.

If the human race had two primitive sources, the one

probably was in Africa, and the other in the eastern part of Asia, or still farther east in lands now beneath the waters of the Pacific. If one only, the best scientific opinion seems to be that it was located on a continent now submerged in the Indian ocean. They spread out over the world, dividing into branches and sub-branches, and finer divisions, like the arterial system from the aorta. Here and there they budded into something like civilization, where conditions were most favorable, but, in the main, progress was confined to that which necessarily arose from the requirements of the struggle for mere existence. This human animal had already reached Western Europe before his form had become more than half erect, as his remains found there prove. Often they advanced into new territory and succumbed or retired, and other invasions followed, until the occupation of the new territory became permanent. The survivors of the earlier invasions, unable to progress, often remained in a state of savagery or inferiority, and had to submit to the superiority in arms and civilization of later colonists.

Three great branches lodged in Central and Southern Africa, in a climate where necessity did not require exertion, and are represented by the Kaffirs, Hottentots and Negroes. The adaptation to the conditions of their existence requiring little effort, their development was slow. Similar easy conditions in the East Indies, Australia, and the South Pacific Islands, or in the primeval continent of which they represent the highest peaks, caused like results as are exemplified by the Papuans, Australians, and Malays. The Mongolians spread to the north and north-east, covered Eastern and Northern Asia, and crossed into America when the continents were probably connected by isthmuses where are now

the Aleutian Islands and Behring Strait. From this point they spread over North America and then South America. This great branch of the human family remains represented by the Mongols, Esquimaux and aboriginal Americans. The last and most important great branch, leaving in its wake the Dravidas of Ceylon and the southern part of Hindostan, occupied Southern and Western Asia, both sides of the Mediterranean and Red Seas, and Western Europe, throwing a small branch through Egypt into Nubia. To this branch of the human family belong nearly all the great nations and most progressive peoples of either pre-historic, or historic times. It includes the Caucasian race and those most nearly allied, and has been called Mediterranese. The Semitic, branching into the Arabic and Egyptian, and the Indo-Germanic or Aryan belong to this superior species of man. The Indo-Germanic branch has far surpassed all others, and is now dominant throughout Europe, the Americas, Australia and a large portion of Asia. All other races will eventually succumb in the struggle for existence. Numerical superiority must give way to intelligence ; and those not plastic enough to become adapted to the new order of things must perish—or live under conditions that superior races would scorn.

The Indo-European branch attained superiority by reason of its enforced adaptation to conditions that lie at the foundations of all civilizations. Its geographical location gave control of the carrying trade by land and water between the southern part of Asia and the western part of Europe. This growing commerce brought to them all that was new and useful from either continent. It built up such nations as Phœnicia, and enabled them to extend their commerce, colonies, and influence. The

islands of the Mediterranean paved the way for short voyages in small boats and this naturally led to the invention and construction of better boats and to longer and more venturous voyages. The Mediterranean, with its advantages of position, islands and archipelagoes, and its northern coast ragged with peninsulas and minor indentations,—was the cradle of commerce. Its shores became the center of the power and enlightenment of the awakening world. It was here that at last an historical period became possible. After the genus Homo had gone through hundreds of thousands of years of almost hopeless but necessary struggle, one of the branches of this human tree had produced buds. Looking backward from the written record to the rock-record we see not the fall and defeat of man, but exactly the reverse, the rise of man, the victory achieved.

## *CHAPTER XIII.*

## HISTORIC TIMES.

PRE-HISTORIC and historic times are dovetailed together. There is no well-defined boundary between them any more then there is between the geological periods. We have to deal with a process of evolution in either case. The art of writing, like the building up word by word of the languages, was attained by small accretions. It grew up from crude beginnings, and it becomes therefore impossible to fix an exact date. The more the subject is studied the more evident the truth of this proposition becomes.

Crude picture-writings were the first attempts at anything like historical records, and tens of thousands of years must have elapsed before picture representations had been shortened and modified into such hieroglyphics as were used by the Egyptians and Aztecs. Hieroglyphics were in use in Egypt three or four thousand years before the Christian era, and perhaps still earlier. They were modified into alphabetical writing, probably by the Phœnicians, at an early period, and from them the principal alphabetical systems now in use were derived.

One of the sacred books of India, the Rig Veda, is probably the oldest literary production in the world. It is of a poetical and religious character, and of little historical value. It is supposed to date from about 1400

B. C., and comprises 1,028 hymns. The Vedas lay down the doctrine that there is one God above all other gods, "who created the earth, the heavens, the waters," and pervades all things, and that he is inseparably connected with nature, including the matter as well as the force, the visible Universe being the corporeal manifestation of God. The soul of man is considered as a temporarily detached particle of the universal divine soul. Exposed to earthly contaminating influences it becomes unfit to return to God, and so arises the doctrine of transmigration to other animals to extend the period of penance and purification. Finally, "absolute happiness is attained through absolute rest."

They have a trinity personifying the attributes of the principal deity, and a number of subordinate or demigods. They inculcate prayers, charity, fasting, sacrificial offerings of money, fruits and flowers, and religious tolerance.

India is the mother of religions, and from the ancient fountain-head have sprung a vast multitude of creeds embracing almost every imaginable theological idea. From this soil, rich in imagination and profound contemplation, but poor in investigation and scientific facts, have spread out branches to Egypt, Jerusalem, Athens, Rome and westward, enduring until the present time. Centuries before Christ they had their immaculately conceived Chrishna and their divine trinity.

About ten centuries before Christ, Buddhism arose and spreading into the populous eastern part of Asia has become the professed religion of the majority of the human race. And yet it has been propagated by preaching and missionary effort and not by the sword. However, it was powerfully assisted by the persecutions of its rivals and enemies. Buddhism claimed the exist-

ence of a supreme power, but not a Supreme Being. Its trinity is the Past, the Present and the Future. It taught that all men were equal; denied the interposition of Providence; things came about by unavoidable cause, not chance; that there is no such thing as individuality, and that at death or after any useful and preparatory transmigration, the soul ends finally in extinction.

The mother of Gotama, the founder of this religio-philosophical system, was represented by later believers as an immaculate virgin, and the belief prevailed that Gotama partook of the nature of both God and man; that he could at birth stand on his feet and speak, and at five months of age sit unsupported in the air; that there is a heaven of music, feasting, etc., for the good, and a hell of burning sulphur for the wicked; that there is a queen of heaven; that prayers may be offered by rote.

Among the most ancient books extant are the poems of Homer and some of the Hebrew Scriptures.

The student of ancient history is struck with the essential similarity of the prevailing conditions of the principal nations. The larger portion of the life history of each of the great nations of antiquity is made up of a catalogue of wars. The resources of the people, produced primarily from the soil by the agricultural population, and added to and made available by manufacture and commerce,—the product of brain and brawn, of hard and honest labor, was squandered in the erection of useless monuments and temples, and wasted in devastating wars. The common people had but a scanty living, and little opportunity for improvement. Kept in ignorance, and in dread of the anger of imaginary gods, they were easy to deceive. Their rulers were often tyrants. Afraid of gods and kings,—twin relics

of barbarism, they were contented with their lot, and bowed in homage to those who were in reality often their inferiors. It was impossible for them to make the effort necessary to rid themselves of the blinding glamor of pretentious authority, revered antiquity, and sacred rites and customs. Broad minded men found safety in silence, for superstitious ignorance is always intolerant. Those who proclaimed a newly discovered truth from the house-top met with the reward of martyrdom.

More discreet reformers worked in tactful ways to advance the standard of intelligence, while the adherents of the well-fed and prosperous kings and priests were pulling backward. On the whole, the gain during the portion of the historical period preceding the advent of Christianity, was about the same as would be expected from the operation of the unaided natural laws of evolution. The advance made by the favored Mediterranean nations was, of course, greater than that of others. It was, however, unequal ; remarkably great in some ways, but in others strangely deficient.

Egypt, for several thousands of years the center of ancient learning and civilization, has seen the Phœnicians, and later her young rivals on the northern shores of the great inland sea, Greece and Rome, pass her in the race. The old and ossified fell by the wayside, while the young and plastic forged to the front. The Assyrian, Babylonian, Chaldean and Hebraic civilizations had their day and left their impress upon those that came after.

Among all the nations of ancient times Nature was always pictured—with the Earth as the center, and man as the most important object of all. Everything was made for him. To suit his convenience or ambitions the miraculous change of the course of Nature was

a reasonable event. Terror-stricken at the formidable operations of Nature around him, which he did not understand, escape was looked upon as the result of the miraculous interference of his deities. They helped to protect him while he subdued the wild domain they had made for him, and over which they had given him dominion. Few actions were so trivial as not to require the guiding and protecting attendance of their deities. There is abundant evidence of this fact in the Bible, in the Greek literature, or in any ancient records.

The belief was general that gods, heroes, monsters and men, mingled together in council, in battle, and in all the important affairs of life. The Earth was flat, the blue sky was the floor of the heavens, resting on the mountainous rim of the Earth, and sustaining the lantern-like stars, and the little Sun and Moon. The wind was the breath of God. In the interior of the Earth, Pluto reigned over the shades of the departed, ferried across the river Styx by Charon. In that abyss all sorts of ingenious tortures were inflicted upon those who had offended the gods.

Hundreds of mythological fables were piously believed. There were harpies, and prophets, and witches, and stone tablets from heaven, an universal deluge, and self-moving rocks; bulls with brazen feet, impossible giants, dragon's teeth that leaped forth as men, gods piloting ships, apples of gold, ants as big as sheep, sorcerers, sirens, cyclops, enchanters, brides and children of the gods, burnt offerings, human sacrifices, divine oracles, and ordinary coincidences magnified into miracles. Such superstitions prevailed long after the Phœnicians ceased to be the masters of the sea, and Europe began to emerge from barbarism.

In the times of Rameses II, over thirty-two centuries

ago, the Egyptians cut a ship canal from the Red Sea to the Nile, at the cost of 120,000 lives and untold sums of money. This great work was the worthy precursor of the present Suez canal, and approached it in engineering skill. It is a relief to notice such great expenditures of human energy to promote peace and commerce,—in a country where so much had been lavished on useless temples and monuments.

Egypt was the cradle of agriculture, the mechanical and architectural arts, navigation, writing, and the Mediterranean civilization from the ruins of which our own has arisen. The observed coincidences between the positions of Sirius and the annual inundation of the Nile, and between the tides and the positions of the Sun and Moon, led to the worship of the Sun and stars, and of the invisible divinity from whom visible nature was supposed to emanate. The Egyptians believed in the immortality of the soul, the fall of man, a few trinities, fasts and penances, transmigration of the soul through animals for purification, sacrifices, mysteries, oracles, omens, resurrection and future judgment. Children groping their way in the dark.

The later and higher civilization, philosophy and religion of ancient Greece, was in part an offshoot of and was modified by the systems of Egypt and Southern and Western Asia. After the original colonization there were repeated invasions of ideas from the southeast, that left their marks on the younger and more ambitious nations of the nature-favored Grecian peninsula and archipelago.

The Greek philosopher, Thales, about B. C. 640, considered water as the first principle, and that the Sun and stars were living beings, deriving their aliment from the sea at the time of their rising and setting. A cen-

tury later the popularity of the water theory was shaken by the assertion of Anaximenes that air was the source of things; that the human soul, water and the earth itself were composed of air, and that the air infinite in extent is God. The Earth was "like a broad leaf floating in the air." This doctrine led to the belief that the Earth and the planets were possessed of souls and consciousness, and was readily accepted in an age when belief in fetishism was general and of a grade more primitive than that of the present day.

The belief prevailed that not alone the air was a spiritual being, but as chemists discovered gases they were believed to be ghosts; some of whom gathering in mines and wells were capable of inflicting great injuries and destroying life. The dawn of philosophy, Science and religion was full of crude and childlike speculation. Anaximander taught that the Earth is of the form of a cylinder, held in the center of the Universe by the air; and that the Sun, Moon, planets and fixed stars are each fastened to a crystalline ring and revolve around the Earth, the Sun being farther off than the fixed stars. Similar cosmological notions are endorsed, explained or apologized for in these so-called enlightened times.

In their turn the Hindu, Egyptian, Jew and Greek passed along the same meandering intellectual path. Evolution is shown as distinctly in mental as in cell growth.

About B. C. 540, Pythagoras was born. It was asserted by his followers, with the usual show of testimony, that he performed miracles, predicted future events, and was present with the people and addressed them in several different places at the same time. To the Pythagoreans, numbers were actual things, so they laid great stress upon their value, imputing great sig-

nificance to the number seven. They strangely hit upon the correct idea that the Sun was in the center of the system, and that around it the Earth and the other planets revolved. They believed the Moon to be inhabited by giants, that the Milky Way was formerly the path of the Sun, that the Universe was eternal, and spherical in shape, that the Earth was transitory, that the soul of man is a part of the universal soul and could exist without the body, and that there are good and evil spirits as made manifest by dreams and sickness. They believed in life after death, transmigration, and future rewards and punishments.

With the Pythagorean abandonment of the geocentric theory of the Universe, mankind seemed to be at the dawn of a new era of investigation and scientific discovery, but alas the glad time had to await the sad struggles and martyrdoms of many centuries of darkness. Trustworthy observation and research gave way to the fruitless wanderings of metaphysics and the dreams of theology, and precious time and talent were wasted in futile and vain imaginings.

Great thinkers, without the guidance derived from the study of nature, reasoned themselves into the most absurd notions. Xenophanes regarded the Earth as the flat surface of a mass extending indefinitely downward. His followers disdained the study of nature, believing visible phenomena to be illusions, and that time, motion, and space do not actually exist,—our senses being deceived. There was no such thing as bodily existence.

They believed that some of their teachers and priests never died, but ascended bodily to the skies, yet denied that anything could be proven to be true. The only things to be believed in were their own feelings or

subjective sensations; all objective impressions were pronounced unworthy of trust.

The disciples of Plato, (born about B. C., 426,) believed that their master was born of a virgin, and was the son of the god Apollo. Plato taught the unity and eternity of God, the immortality of the soul, transmigrations, future rewards and punishments; that objects were the embodiment of ideas, that ideas are the only real existences, that former states of existence can be remembered, that what we see is not real, that there is only one world, that the world is an animal with a soul, that there is a race of subordinate gods, that the Earth is the oldest of all bodies and the center of the Universe, the use of the liver is to receive and reflect the images of thoughts; and he thought the individual should be in every respect subordinate to, and the creature of, the state.

The philosophical confusion that naturally led to the idealism of Plato as its culminating point, was succeeded in the next generation by the inductive philosophy and materialism of Aristotle. Instead of commencing to build in the clouds, he laid his foundations on solid rock. First collect the little facts, the material, the particulars, and then proceed upward to universals,—the true scientific method of inquiry. Aristotle was the John the Baptist of Science. Unfortunately he could not do justice to his own methods, for the world was illy supplied with facts; he had little foundation on which to build. The necessary result was a wonderful structure strangely combining truth and error, the strength of manhood with the fancy of youth, but it marked the high water point of human advance up to the age in which he lived. His knowledge of the operations of Nature was too limited to enable him to free

himself from most of the current erroneous views relating to the cosmos, but his genius cleared the way for the recognition of the vast importance of carefully ascertained facts.

The conquests of Alexander resulted, on the breaking up of his empire, B. C., 323, in the establishment under the Ptolemies of the great Alexandrian museum and school of philosophy and Science. No effort was spared to make Alexandria the intellectual center of the Earth. Asia and Europe were searched for volumes to add to the Alexandrian Library, until a total of 700,000 volumes was reached. Learned men from every nation of the known world came to Alexandria in pursuit of their studies. There was a free and liberal interchange of ideas. The attainments of the East were supplemented and modified by the profound speculations of the Grecian philosophers.

The mythology of Greece gave way to the older and more mature creeds of the East. In this general commingling of the best intellectual attainments of the race, Science had its origin. It was the opportunity of the seekers for the truth.

The wars, the conquests, the new sights brought under the observation of the conquerors, the efforts necessary to success, the impetus to commerce, the building and rebuilding of cities, the general diffusion of knowledge, the breaking down of political barriers, the necessity for great deeds, the friction of active minds, the new channels of thought and endeavor,—all tended to expand and strengthen the human mind. The best knowledge, heretofore confined to a few limited localities, became the common property of all. Science was unshackled, while creeds were being readjusted. There was life in the new city, and its influence was everywhere felt.

To its native Egyptian population was added hundreds of thousands of Greeks and Jews. The city was filled with splendid palaces, temples, theaters, avenues, gardens, obelisks and fountains; and its great lighthouse, built of white marble, was one of the seven wonders of the world. The mausoleum, in which rested the body of Alexander, was surpassed in interest by the museum and library. The fame of the great conqueror, perpetuated in the grandeur of the mausoleum and the name of the city, has found its imperishable monument in the increase, perpetuation and diffusion of knowledge, arising from the founding of the museum and library by his half-brother, Ptolemy Soter.

In connection with the museum were a botanical and zoological garden, an astronomical observatory, a chemical laboratory, and an anatomical dissecting room. The globular form of the Earth was maintained, but the Earth was still believed to be fixed in space; 1,022 stars were catalogued, and eclipses and the motions of the Moon and planets studied; and to the Alexandrian school must also be credited the works of Euclid, Archimedes, Eratosthenes, Hipparchus and Ptolemy. The most important philosophical advance was attained by the adoption of the method proposed by Aristotle, of beginning with the study of the particulars of phenomena, and with that knowledge as a base rising to the consideration of general principles. This is the foundation of the modern scientific method. Grecian power and influence had reached the highest point and the outlook for civilization was encouraging.

By the middle of the second century, B. C., the Roman conquests had included Greece and Macedonia, and a century later (B. C., 48,) Alexandria was besieged and taken by Julius Cæsar, and in a few years more, all the

Mediterranean nations were absorbed and became parts of the Roman Empire, which extended from Britain to the Persian Gulf, with a population of about 120,000,000.

These disastrous wars and political changes were followed by an era of peace, with Rome as the center of power and learning, and Alexandria second only to the capital of the empire. Each conquered nation had its king and its own peculiar deities and religion. Captives and treasures were brought to Rome and all kinds of worship were tolerated.

The power formerly exercised by numerous rulers now became centralized under one emperor, who was even worshiped as a deity. Following the political tendency —the theological ideas changed from polytheism to monotheism. This irresistible movement once established, it is evident that the form of religion endorsed by the emperor, with himself as the almost divine earthly head, would eventually become the accepted religion of the whole empire. It is equally evident that the facts of Nature were yet inadequately understood, and that any cosmological theory, or philosophical system based thereon, would stand no chance of success against any considerable movement actuated by zeal and religious fervor. Reason thus unsupported would be easily disarmed in the presence of enthusiasm, sentiment and faith,—in an age when no error was too absurd to have zealous followers.

Scientific investigation is the work of time, and requires great and pains-taking labor. Theological speculation is easy and rapid, and with "the wish the father to the thought," fixed conclusions are easily reached. The times were unsettled. A multitude of dethroned gods left the people free and ripe for the introduction of

a new or unknown god, and a vital religious movement that would strongly appeal to human passion and feeling, and that could promise rewards commensurate with all the most vivid imagination could desire. Supplement this hope with the promised punishment for lack of faith in the new religion, and we have the most powerful appeal possible to the hereditary fear that lies at the foundation of all supernaturalism. The doctrine preached, that the time was near at hand when the Earth would be destroyed by fire, was another strong lever to act upon the fears of the superstitious. The idea of an unknown god was the natural crown of a structure based upon the primitive fear of the dark, or unknown, and therefore, the unrestrained imagination could picture him full of love and fatherly kindness for the faithful, while at the same time jealous of other gods, and ready to punish unjustly, endlessly and hopelessly those, who, however conscientiously, failed to openly acknowledge his supremacy.

The ruling motive of many converts to any faith is —that they may eventually be found on the safe side.

The operation of the same natural laws can be traced in the evolution of theological ideas and emotional religion, from their origin with primitive man, to their culmination in the Dark Ages and their present decline.

The great trunk of Christianity as it arose above all rivals at Rome, was the blended product of many fertile soils. A large root derived its nourishment from the ancient, and in some respects more philosophical, creeds of India, another came from Egypt, another from the polytheism of Greece and Rome, a goodly portion of the feeders from Jerusalem; all, revivified by the simple, earnest, communistic, virtuous, unceremonious faith of

the lowly Nazarene. The new faith started out with the great advantage of being unnoticed because of its comparative obscurity, and its later success was guaranteed by the unselfish zeal, and unwavering faith of its early propagandists, who went forth with resolute confidence to proclaim their gospel to all men.

The new religion was opportune in the fact that it taught the brotherhood of man, at the time when political, religious and race barriers were broken down by the general assimilation of the civilized world in the Roman Empire. For these and kindred reasons it spread quietly and rapidly, invading the palace and the hovel, and before it had been considered by those in authority as an important political factor, its adherents were numerous and strongly intrenched, with its missionaries in every part of the Empire. Starting in a passive age, and being essentially active and aggressive, and socially well organized, to attain supremacy it only remained to secure control of the machinery of state. Commencing with gentle persuasion and peace, success brought arrogance, dissension, force and bloodshed.

The wife and daughter of the Emperor Diocletian were Christians, when in A. D., 303, Christian soldiers mutinied and refused to join in the customary pagan worship. Christian officers were cashiered and persecuted, and massacres followed. Two years later Diocletian abdicated, civil war followed, and the victorious Constantine, the competitor for the purple, who received the support of the Christians, ascended the throne, and the ascendency of paganized Christianity was assured throughout the great empire.

As time elapsed Christianity became more paganized and less like the simple, charitable and communistic creed of the early disciples. There were imposing

rituals; the Trinity after Egyptian traditions; a female deity; angels, martyrs and saints in the places of the lesser gods of the pagans; a probationary future state in place of transmigration; the ancient symbol of the cross; fasting, celibacy; pilgrimages, consecrated water and the miracle-performing dust, bones and other relics, an offshoot of fetich worship; transubstantiation, canonization, worship of the dead; in a word, everything demonstrated the truth that a step, and a short one at that, had been taken in the evolution of religion. This step carried with it the fetich-like reverence for the Bible, as containing a divine revelation of all that it was good for man to know.

With the Church backed by the civil power, it was no longer safe for men to doubt, and follow the light of reason and investigation. First emotional, and then doctrinal religion was in the saddle, and young Science was strangled in the birth. The crude geocentric theory of the Universe with all that it implied, was the scientific lesson of the sacred book, and it had to suffice. Splitting hairs over slight shades of difference among theologians took the place of philosophy. The influence of the Alexandrian effort was diverted and lost to the world. A thousand years were required before the rubbish could be cleared away and the attempt to build upon the solid foundation of investigation could be again resumed in Europe.

At the time Alexandria was taken by Julius Cæsar, the larger portion of the celebrated collection of books was destroyed by fire. To make amends as far as possible, Mark Antony presented the great (200,000 vols.) rival collection of Pergamos to Cleopatra to be added to the Alexandrian Library. About A. D. 391, the Christian Bishop Theophilus, with the consent of the

Emperor, dispersed and destroyed the great library, or, almost all of it. What was left was destroyed by order of the Mohammedan Caliph Omar, A. D., 642, who said: "If the books agree with the Koran, the Word of God, they are useless, and need not be preserved; if they disagree with it, they are pernicious. Let them be destroyed."

There can be no doubt that the greater portion of this most valuable collection of manuscripts was destroyed by the permission and active participation of the Christian patriarchs of Alexandria. Yet, this irreparable injury to mankind, this colossal crime, stands not alone in the annals of the harm that religious bigotry has done. The great and valuable library at Tripolis was entered by Christian crusaders A. D., 1109; the first room contained the Koran, and the whole collection was burned. Thousands of valuable Arabic manuscripts were publicly burned at Granada by Cardinal Ximenes. In Mexico the Spaniards burned large quantities of American picture-writings. The faithful have been ever ready to destroy secular and scientific records. The other side must not be heard. The progress of religion through the ages has left a wide trail of blood and ashes.

Not content with the destruction of the Alexandrian Library, Saint Cyril, the loathsome nephew of the infamous Theophilus, caused the philosophical teacher Hypatia, a follower of Aristotle, the daughter of Theon the mathematician, to be stripped naked in the streets of Alexandria, dragged to a church and there killed. Her body was cut to pieces, the flesh scraped from her bones with shells, and the quivering mass cast into the fire. This was the end of Greek philosophy, the end of reason and Science, in Christian countries, for many precious centuries. It was one of the most effective arguments the world has known; and Christianity

profited by it. Teaching the truth by word or book ceased.

It was not all smooth sailing. There were conflicting opinions, interests, and ambitions, and the Roman Empire found itself launched on a stormy sea. Many minor contentions were disposed of from time to time, when a sect arose in Arabia, led by the prophet Mohammed, opposing the doctrine of the Trinity, and the divinity of Christ, and asserting the unity of the deity. "There is but one God, and Mohammed is his prophet," was the cry of the faithful. The successors of the Prophet fought for their religion and conquered. Jerusalem, Alexandria, Carthage, and later Constantinople were wrested from the hands of the Christians. The Mohammedan empire became larger than that of Rome itself. Only the almost accidental success of Charles Martel (A. D., 732) at the great battle near Poictiers, in France, prevented the complete conquest of Europe by the invading Saracens.

Fortunately for mankind, one of the results of this unpromising Asiatic movement, was a renewal of scientific research, under the later and richer caliphs, which accomplished a little more than to restore our knowledge of astronomy and mathematics to the position it had attained in the time of Ptolemy. They determined the shape and size of the Earth, mapped the visible stars, and made advances in mathematics, chemistry and medicine. They also succeeded in finding, translating, and preserving, some of the Grecian philosophical and literary works.

While the Mohammedan revival of learning was in progress, Christendom was passing through the period known as the Medieval, or Dark, or Middle Ages. They lasted for about 1,000 years, ending with the discovery

of America in 1492. The common people lived in huts and hovels, cold and poverty-stricken, without floors or windows, with fires built upon the ground, and poorly supplied with food and clothing. Ignorance and want were the rule. The power and wealth were in the hands of the aristocracy and clergy.

The rights of man were at a low ebb. Wrong, robbery, extortion, and oppression were submitted to without question and as a matter of course. Filth, parasites, disease, faith, justice, (?) by wager of battle, serfdom, poverty, ignorance, witchcraft, superstition, wars, everywhere prevailed, and the suffering people, blindly hoping for happiness beyond the grave, were contented with their lot. What a commentary on contentment! What had nearly fifteen centuries of Christianity done toward emancipating mankind from ignorance and tyranny? Few unbiassed historians will deny that the evil it had encouraged and permitted, greatly overbalanced any good results with which it may be credited. It had feared, opposed and persecuted the scientific investigators, and was thereby an active agent in the perpetration of an irreparable wrong.

While this state of things lasted there was little safety for person or property. The condition of women was deplorable. The various religions of the world have had a tendency to repress the self-reliance of women and prevent their intellectual development. The laws of natural development were thus interfered with to the detriment of the succeeding generation. Thanks to liberty and patriotism under the Republic, the ancient Roman matron was the mother of heroes. The same cannot be said of her submissive Christian successor. The Era of Science is making itself felt in the emancipation, elevation and education of woman.

If the destruction of millions of human lives and the waste of untold millions in treasure and property, with all the attending horrors and suffering of needless war, are good and useful deeds, then the Church should enjoy full credit for the wars of the crusades—and many others.

In the eleventh, twelfth, and thirteenth centuries, mad efforts were made to recover the sacred relics at Jerusalem from the possession of the Saracens. These wars were called Crusades, because each soldier wore upon his shoulder, or breast, a cross, and from this he was called a crusader. Eight distinct crusades were organized, and conducted with varying degrees of success, involving the loss of millions of lives that if properly directed might have been useful. On the whole, and as a final result, the foolish efforts were a dismal and total failure; none of the objects of the wild and shameful raids having been accomplished. Indulgences were granted to those who went; many were the prayers, and boundless the faith, but of no avail. If in response to their supplications the Lord helped either side, it must have been the Mohammedans. It is said that an army of little children was raised with the idea that innocence might, through the favor of heaven, triumph where valor was of no avail; but they perished on the way to the Holy Land.

No story was too big for the gigantic credulity of that age. There were, of course, many miracles. One, perhaps entitled to as much credit as any, is related about one of the leaders of the holy crusaders, who had been beheaded in Palestine, being seen returning home carrying his head under his arm. No wonder the crusaders burned the valuable library at Tripolis. It is impossible to sum up in the mind the total loss to the world resulting from the crusades.

Every student of history is familiar with numerous wars, massacres, assassinations and persecutions instigated by the churches to prevent the spread of rival doctrines. It is enough to simply mention here the atrocious massacre of the Huguenots on St. Bartholomew's Eve, A. D., 1572. The sane mind revolts at such barbarous deeds, and dislikes to dwell upon them longer than necessary.

Columbus, accepting the idea of the globular form of the Earth, believed that by sailing westward the East Indies could be reached, and the commercial interests of Genoa helped by the new route. Years of disappointment and ecclesiastical opposition passed. The final discovery of America, in giving a new impetus to commerce did the same for civilization. Magellan circumnavigated the Earth and forever set at rest the question of its shape. The old Egyptian and Arabic astronomers were right—and the Church fallible and wrong. An opening had been made for the revival of Science. Soon, measures of the curvature of the surface of the globe were again made and its size approximately determined. The agreement was close with the results long before reached by the Arabic scientists.

Still, the Earth was believed to be in the center of the system, and man the great object of creation. Men were coming back to Mother Earth at about the same point from which they started on their vain celestial flight a thousand years before. Think of the waste of time and labor—blood and treasure.

About the year 1507, Copernicus completed a book —*On the Revolutions of the Heavenly Bodies.* For thirty-six years he dared not publish his work for fear of persecution by the Church of Rome,—and by the equally hostile Protestant leaders at Wittenburg. At

length he decided to publish it. The printed book was placed in his hands May 24, 1543, as he lay on his death-bed, a few hours before he expired. The book established the truth of the heliocentric theory. The Church declared that it contradicted revelation, and solemnly condemned it as heretical. To read it was to risk damnation. Fortunately for him, its great author was beyond their reach. Luther called Copernicus an upstart astrologer, and a fool, denied that the Earth revolves, and remarked that "Sacred Scripture tells us that Joshua commanded the Sun to stand still, and not the Earth."

The powerful denounced and attacked the true theory of the solar system; the ignorant ridiculed. There must have been many who were convinced that Copernicus was right. Was there one in all Christendom who dared to openly maintain the truth?

There was one and one only; let his name never perish, —Giordano Bruno. He publicly held the infinity and plurality of worlds, and that we are surrounded by, and only by, space and stars. He was arrested and confined for years in a dungeon, without books, paper or friends, to make him recant. He would not renounce what he knew to be true to save his life. He was publicly burned at the stake in Rome, February 17th, A. D., 1600, as a heretic. When enveloped with the flames, he turned his face away in disgust from a monk who held out to him a crucifix. He died as he had lived—a defender of the truths his murderers feared. Noble Bruno, thy murderers were no less savage than those who,—over a thousand Christian years before, mangled the beautiful Hypatia.

About ten years after the martyrdom of Bruno, the little telescope of Galileo, magnifying only thirty times,

had demonstrated the truth of the theory of Copernicus. The whole theological pack, of every shade of doctrine, set up a howl that has never been surpassed but once, and that was in our own day on the publication of Darwin's *Origin of Species.* The new scientific facts were dutifully overthrown by a class of men who knew nothing about it, and by another rather intelligent squad who knew better, but wanted to retain their jobs and corporeal bodies. Some profound theologians were unable to trace the inhabitants of the other planets back to Noah's ark, or satisfy themselves how they could be subject to the plan of salvation. The fight centered around Galileo. The epithets "Infidel" and "Atheist" were freely used, but they failed to extinguish the light of the hated telescope. Galileo announced that there were mountains on the Moon that was made to rule the night, and spots on the Sun that was created perfect. There was no end in sight. So Galileo was summoned before the Holy Inquisition and compelled to recant. Sixteen years later, in 1632, he published his work, *The System of the World.* He was again summoned before the Inquisition, accused of claiming that the Earth moves around the Sun, and obliged to recant, under pain of death, on his knees with his hand on the Bible. For the remaining ten years of his life he was kept in prison, or under surveillance, and at his death, at the age of 78 years, he was denied burial in consecrated ground. To a sensitive, aged man such treatment was torture.

The Church has persecuted men of Science, and Christian sects have persecuted each other ; but Science is guiltless of such crimes.

Almost every important advance of Science has met with the powerful opposition of the Church. In every

resulting conflict Science has triumphed, and the Church, compelled to accept the newly discovered truth against her will, has in after years, claimed credit for being the educator and civilizer of nations. Modern civilization, dating from the triumph of the Copernican idea of the solar system, in all its distinguishing features, is the product of scientific research. Christian opinion has been kept busy, first opposing, and then trying to catch up. It has ever been and now is hopelessly in the rear. Driven from one position, it takes up the one nearest the one proven to be false, only to be obliged to abandon that in its turn. In its strange over-estimate of the relative importance of human beings and their notions or beliefs, it has utterly failed to get a correct understanding of the real character and meaning of the operations of Nature. In these days, in place of physical torture and the fagot, we have for Freethought and free expression, for ultimate scientific conclusions;—the persecution by social and political ostracism, the boycotting of business men, and the insidious attempts to control the state and schools. Such persecution is the evolved natural product of the intolerance that in the early Christians led to the martyrdom of Hypatia, Bruno, Servetus, and thousands of others.

A good reason why the punishment for heresy is less severe than formerly, is that the churches lack power. In the interest of Science, liberty and safety, their power for evil should not be prolonged by resources drawn from the state, nor by contributions from liberal minded persons.

The refined persecutions by the churches is to-day so potent, that men in business or in politics; or those desirous of social recognition, or of amassing wealth, often keep closed mouths, or conform to views and

customs they have outgrown. We have, thanks to Science, at last outstripped the ancients in everything, excepting religion. Orthodoxy, grounded in supernaturalism, still adheres to its idols. Christianity in nearly 2,000 years has given the race less of value than pure Science unaided and often opposed has done in the last half of the present century. Why do we still cling to the dead theological limb on the tree of human evolution? We of this generation have a duty to perform for those who come after. Majority rule is the pruning-saw. Let the dead and burdensome limb be severed near the trunk, that the world may have peace and progress.

Any intolerance toward innocent Christians should be avoided. Neither do wrong nor suffer wrong. It is only necessary that we should have the courage of our convictions, and reason will assert itself and truth and right will prevail. It can no longer be doubted that all the principles of natural selection have been in operation during the historical period, and the result has been, that taken as a whole, there has been decided progress. It is further evident that the greatest advance has been made at times when Nature has been the most carefully studied, and her mandates obeyed. The human race has improved physically, mentally, and morally.

Faith accepts the old creed or the old plow without question. Doubt leads to investigation, then experiment, and something better is discovered. This is the method of Science. It has given mankind during the historical period, through progressive improvments, in place of the old wooden plow—the steel and the steam plows. Note the evolution from sickle and threshing-floor to reaper and harvester; from quill-pen to type-writer; from the hieroglyphics of Babylonian pressed bricks to the perfecting printing press; from the crude steam engine of

Hero to the modern steam engine; from the mounted courier to the telegraph and telephone; from the wooden cart to the equipped railway; from the galley propelled by oars to the ocean steamer and the battleship; from the hand-loom to the power-loom; from a simple lens to the achromatic telescope and the compound microscope; from the tallow candle to the electric light; from the stage-coach to the electric cars; from the sword and javelin to the machine gun; from manuscript to newspaper, magazine and book, and so on indefinitely.

Very great advance has been made upward from the mire of superstition. We have reached the dawn of a new era. Let it be recognized. The present chronology, founded in mystery and superstition, is unworthy of this age. There should be no man, creed, or nation so highly honored as to mark the commencement of a new era. It should commemorate the work of the race, and be an earnest of the future. I venture to suggest that the year 1901 would be in several respects the best and most convenient time to make the change. Sooner or later it is bound to come. The year A. D., 1901, by dropping the first three figures, passes easily and naturally into S. E. 1, the first year of the proposed Scientific Era. The current year might be designated B. S. E. 3.

Closing our eyes does not dispose of the fact that a new and better period than mankind has ever known is at last in sight. The frightened, like the pursued ostrich, have the privilege of hiding their heads. The wise will gladly greet the rising light.

## *CHAPTER XIV.*

## CRYSTALS AND INORGANIC COMPOUNDS.

WE cannot become too familiar with the methods of Nature, whether on an extensive scale, or, as is often more instructive, on a minute or microscopic scale. The movements and combinations of atoms and molecules, small when individually considered, certainly determine the ultimate character of the greatest results.

However difficult of explanation we may think the various phases of organic nature to be, the operations going on in inanimate matter are scarcely less complicated and wonderful. The powers and properties of matter are closely allied, or identical throughout the mineral, vegetable and animal kingdoms. Any apparent gaps in the uniformity of Nature are illusions arising from our own imperfect knowledge. Every advance in knowledge has helped to fill such gaps, until, as we now survey the field no impassable ones are discernible. All the probabilities are in favor of continuity.

The growth of a crystal shows as much selection, skill and uniformity as the growth of the siliceous shell of a diatom,—and the affinity is close. Matter subjected to the subsidence of heat energy, to cooling off, changes from the gaseous to the liquid form, and then from the liquid to the solid through crystallization. Solids are also sometimes formed by direct crystallization from vapors. On cooling or evaporating a saturated solution, crystals must be formed, and they will vary in character accordingly as the conditions are changed.

Each mineral species has its characteristic form o crystals, which never vary when formed under the sam conditions. The addition of a trace of some other sub stance, or an attempt to hasten the process will be see in the product. It is easy to obtain characteristic cry tals of most substances for examination with moderat microscopic powers. They are beautiful and instructiv objects, and will well repay the student.

Common salt, crystallizing from pure water, takes th form of cubes by slow evaporation; and by rapid eva oration, hollow, four-sided pyramids. Sugar crysta lizes in four-sided prisms, or it may remain for a tim in an amorphous or uncrystallizable state. Sulph may be soft and amorphous, or in crystals; or, when sul [illegible] and condensed from its vapor in closed chamb [illegible] consists of minute globules, from a two-hundredth [illegible] of an inch in diameter. Beautiful arbo [illegible] forms of metallic silver crystallize around a bit [illegible] in a solution of nitrate of silver. Simil [illegible] vegetation may be had in gold from [illegible] of the chloride, or in lead from a solution of th [illegible]

[illegible] the frosted window we have ready-made arboresce [illegible] from aqueous vapor, and in the snow a gre [illegible] six-sided, six-armed, beautiful, [illegible] Water, therefore, crystallizes in he [illegible] forms, and in ice the individual crystals a [illegible] crystalline. Inhabitants of the Torri [illegible] believe that water ever can becom [illegible] of the most reasonable places t [illegible] miraculous creation in all nature i [illegible] of the crystal. Yet, familiarity with it ha [illegible] as perfectly natural. Alum [illegible] hedrons, consisting of two four-

sided pyramids united base to base; gold in octahedrons, dodecahedrons, as well as in arborescent, spongiform, reticulated, filiform and acicular shapes; quartz in hexagonal prisms with pyramidal terminations; mercury in octahedrons, and iodine in rhombic crystals. We cannot here give more than a glimpse at the science of crystallography, only enough to call attention to the variety and perfection of form and structure in inorganic nature.

Who has not looked with wonder at large crystals like those of quartz and potassium-nitrate. A single crystal of quartz has been known to weigh 800 pounds. Large crystals have grown slowly because the supply of crystallizing material was gradually introduced and kept up for a long time. The material attaches itself to crystals already started instead of starting new ones.

Place a drop of the solution of ammonic chloride (sal-ammoniac) on a glass slip in the microscope. Small particles appear, and from these the crystals shoot out, forming beautiful branches, the secondary branches forming always at right angles, or at an angle of 45°, with the main branches. Solutions of urea, or of camphor, in alcohol give instructive crystallizations. As we watch the movements and the display of the building power of crystallization, we recognize the fact that there are other forms of life, rather closely related to plant and animal life, and often taking similar forms. The highest effort of plant life is the production of the flower, yet, how close a copy has inorganic nature set in the wonderful hexagonal ice-flowers and snow-crystals.

We are apt to lose sight of the capabilities of matter. Take the lightest known substance, hydrogen, an inflammable gas, and oxygen, a gas sixteen times heavier, that will not burn, itself, but is the feeder of combustion; then chemically unite the two, eight parts of oxy-

gen to one of hydrogen and the result is water, the principal constituent of our own bodies. Think of the many properties of water. Pure white sugar consists of water, and carbon in the form of charcoal, chemically united, the product bearing no resemblance to its constituents.

Carbon occurs in several forms, in the diamond, coal and graphite. It is combined with oxygen in carbonic dioxide, the chief food of plants. It is decomposed in the leaves by the action of the Sun, the oxygen going into the atmosphere and the carbon becoming part of the plant. The great energy required to cause this separation of the two elements is stored in wood and coal to be given out in heat when they are burned, that is when their atoms of carbon are again being united with oxygen.

The chemical changes in high explosives, suddenly expanding them into gas and liberating their energy, attest the importance of atomic separation and combination, and the energy of matter that to an ignorant observer might be considered as inert.

The character of a mass of matter depends upon the quality and combining powers of its constituent chemical atoms. As we approach the higher and more complex combinations, qualities reminding us more and more of the peculiarities of living matter are manifested.

Of all the elements, carbon enters into more known compounds than any other. It is a many sided substance. Its compounds not only present different qualities, owing to the combinations of its atoms with the atoms of other elements, but the atoms arranged in different order produce dissimilar results. The carbon atoms possess the peculiar power of combining among themselves to an indefinite extent. Each of the com-

pounds may be modified by combination with other elements. So we have an indefinite number of combinations of which this remarkable element is capable. In this respect no other substance approaches it. We are prepared then to recognize the significance of the fact that it furnishes the foundation for the gathering together of the elementary substances necessary to the formation of organic compounds.

The carbon compounds form the bridge connecting the organic and inorganic. Over it matter has ascended from its highest mineral state to the lowest vegetable and animal, or protistic plane. Unstable chemical compounds have become a step more complex and vital activity has resulted. However, in its ultimate analysis, that which we call life or vital force, is but another form of chemical, or in a larger sense physical energy.

Organic compounds such as the coloring principle of madder root, have been, of late, made artificially by the chemist in his laboratory, by the combination of the atoms of their constituent elements. Hundreds of substances have been constructed in a similar way.

Living organisms are made up largely of water, and are therefore supplied with the best medium to encourage the free movement of atoms and molecules. Without this, whatever the possibilities of the other substances, life could not exist. The right degree of fluidity is as necessary as the proper chemical and thermal conditions.

A drop of water, oil, or other fluid, left free, will soon be covered with a pellicle formed under the same laws as govern the development of cell walls.

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plasm are perhaps still more wonderful and difficult to understand than those of water, but they are none the less natural and illustrative of the laws of cause and effect.

Protoplasm is a homogeneous, slime-like, jelly-like, albuminous substance, in its simplest form showing no structure under the highest microscopic powers. This delicate substance, coming into existence in the Archæan era, a period covering more than one-half of geological time, and whose rocks have been altered by heat, it could not of course be preserved in a fossil state. All fossils represent its later and more mature work,—the chambers, shells and bones it has secreted and produced.

Living Protoplasm, in a form as simple as we can well conceive of, still exists and can be studied at leisure under the microscope. It is in little masses, individually visible with low powers, and satisfactorily seen with the higher powers of the instrument. These little bodies are called by Haeckel, Protamœbe primitiva. They are homogeneous, without organs, nuclei, or cell-wall; lumps of formless, transparent slime, semi-fluid; yet possessing powers of sensation, nutrition, motion and propagation; all in a very slight or primitive degree, yet, no doubt higher in these respects, than the original primordial forms.

Let us put a thin film of rich pond water on the slide, with a thin glass cover, and after hunting it up with a low power, use our best microscope lenses to study the little Moneron, a true Protamœbe primitiva, and then write down our observations. The uniformity of its substance is evident, and it looks very much like a watery fluid, resembling inorganic matter more than organic. It has no organs of sensation, locomotion, nor

digestion. Its form is constantly changing as different parts of its mass are extended and contracted. For this, or any purpose, one part of its substance is just the same as any other. Where now is an indentation, a minute later may be a projection. These motions seem slow enough; but they are in fact a thousand times slower than they seem to be, if we are using a power of 1,000 diameters, for the motion is magnified the same as the object. The visible results of the action of the Prot-amœbe upon its environments and they on it are also that many times less than they seem to be. We are apt to overlook the fact that we are witnessing after all an exceeding small degree of vital activity. When we realize this fact, and fully comprehend the simplicity of the living being, we recognize the truth that with such matter life on our planet began.

The boat shaped objects that often in moving about strike against our Moneron, are unicellular plants called diatoms. The empty shell of a diatom is smooth and free of protoplasm, and slides away from the Moneron; many live ones by a little jerking motion happen to escape; but finally one sticks fast and is slowly surrounded and enclosed in the little lump of living jelly. After the protoplasmic part is assimilated the siliceous shell is rejected. Yet, the little being is not, strictly speaking, organic. It has no mouth, eyes, stomach, heart, nerves, or any organ whatever. It moves along slowly by means of the extensions and contractions of its substance, which by courtesy we might call pseudopodia. In its wanderings a pseudopodium happens to stick through a tiny opening in the debris with which the water abounds. More of its matter flows through. Flowing is the word that seems best to describe its motion. Finally there is a

bunch of its substance on each side of the obstruction, connected by a thin isthmus. It parts, and the two halves go their ways two distinct beings, possessing all the properties of their parent. I have myself witnessed the primitive method of fission I have attempted to describe.

Such divisions, at first caused by the conditions of existence, proving advantageous, finally become fixed habits or characteristics. Whatever the true explanation may be, the fact remains that all the qualities of this simple being are retained and transmitted with the same conservatism as that which we have observed in the forms of crystals. We have to deal with the same forces under slightly changed conditions—and different chemical combinations.

As both the plants and the animals have developed from Protoplasm, it is probable that the amœbæ are also capable of taking their food after the manner of plants, in the liquid form by diffusion. This quality is not entirely absent even among the higher animals.

A number of species of the Monera have been described, and intermediate species connect them with a species of amœbæ, naked and having the motions of the one above described, but possessing nuclei. The nucleus is a globular lump of plasma containing a speck, —the kernel or germ, and is a condensation and differentiation of the same plasmic matter. It also propagates by division. When it passes into its resting state the pseudopodia are drawn in, it forms a globule, and secretes around itself a protecting membrane. Other little plasmic bodies taking their food in the same way secrete permanent shell-coverings; some of them are, like those of the Arcella, very curious and beautiful. The shell of the Difflugia is composed of small stones.

When the amœba assumes its resting form, we have the primitive representation of the ovum as it first forms in animals and plants—from man downward; and this is not all, we have also a perfect *cell*,—and all plants and animals are either single cells or aggregations of cells. Neither is this all, we have in it a form intermediate between vegetable and animal. If its cell wall is tough and unyielding it has to receive its nutriment by absorption and diffusion like plants. In its naked form it incloses and digests its food. Hence, almost at the start the animal and vegetable kingdoms diverged from a common protoplasmic stock.

In the drop of pond or sea water are many animalcules composed of single cells,—with parts more or less differentiated through the advantages arising from the division of labor. Such functional division being of use to the little being, is the cause of the development of organs fitted to special purposes. The pseudopodia become modified into permanent cilia, the vibrations of which move the animalcule rapidly through the water; or, when feeding, create currents that bring its food into its mouth. From causes that are simple and obvious the development of the various organs goes on. To illustrate the position taken, examine with the microscope any of the ciliated infusoria, the Vorticella, and the Rotifera, when feeding. The microscopist will find no lack of objects illustrating all shades and grades of the primitive development of useful organs.

The capabilities of Protoplasm in its simplest forms are sufficient to justify all that is required of it in the development of the highest. Through adaptability and heredity its secretive skill has become wonderful. The shells of the Arcella and Diatomacæ should be examin-

ed with the microscope. See the wonderful variety of forms among the diatoms; the perfection of the boat-shaped, elliptical, circular, triangular, quadrangular, sigmoid and other forms. Increase the power and study the minute markings and skillful structure of the individual shells, rivaling the perfection of honey-comb—in the Triceratum favus and many others, and in all approaching the work of human designers. Remember that this is all done by single cells of soft, simple protoplasmic slime,—secreting these little boat-houses of silica in such perfect shapes—adapted to their needs and having the greatest strength with the least material.

The hexagonal and other geometrical markings of the diatoms are as true figures as are the same in the crystals of any minerals, and suggest a common parentage in the unity of matter and force.

The perfect work of cell-building and home-building matter is further exemplified in the Radiolaria. The protecting shell they build is remarkable for its beauty, strength and perfect adaptation. Yet, these organisms move through the water and feed by the aid of long, soft, slender, branching pseudopodia; being as evidently pure Protoplasm as the amœbæ. Others have connected, chambered structures like the Eozoon Canadense, a fossil already mentioned. The fossil remains of the shells of the Radiolaria and Diatomacæ make up in numbers what they lack in size, and form thick and extensive strata in some localities.

Much space might be taken up in describing the numerous interesting species belonging to the Protista, —like those we have mentioned, but they can only be really understood through direct personal observation. It may be said of this primitive kingdom of organisms,

that it is neither animal nor vegetable, but intermediate, and more primitive. Naturalists have not agreed in classifying the Protista, they having been claimed by both the zoologists and the botanists. They are all non-sexual. All the life they exhibit is caused by the chemical, electrical, metabolic and mechanical action —disturbing and changing the molecules of the sensitive Protoplasm.

"When the opponents of the Theory of Descent assert it to be miraculous and inconceivable that an exceedingly complicated, many-celled organism could in the course of time, have proceeded from a single-celled organism, we at once reply that we may see this inconceivable miracle at any moment, and follow it with our own eyes. For the embryology of animals and plants visibly presents to our eyes in the shortest space of time the same process as that which has taken place in the origin of the whole tribe during the course of enormous periods of time."—(Haeckel's *History of Creation*, Vol. II, page 40.

The Algæ being the beginning of distinctively vegetable life, furnish us with easy objects for the study of cells and their growth. There are numerous species both in salt and fresh water. They are easy for the beginner to recognize. The green scum on pools of standing water, and the green, hairy-like masses in running streams, and adhering to stones and logs, in ditches, swamps, ponds, springs and lakes, will be found to be nearly pure Algæ. Like the frost on the window, or the fern-like crystallization of metals, are the forerunners of higher vegetable forms as seen in the shapes of some of the lowest of these humble plants. This suggestive feature is seen in a few specimens not built up of cells, but composed of a single cell only; the

Protoplasm itself assuming by reason of hereditary adaptation the shape of a branching plant, with rootlets, stalk and leaves.

Scrape the green slimy coating from a stick that has lain for sometime in a pond, and perhaps several species of desmids may be obtained. With medium microscopic powers no more symmetrical and beautiful objects need be desired, though the wonderful growth displayed by each individual is accomplished by the tiny lump of Protoplasm in the single cell. When maturity is reached the cell divides through the middle and two desmids result.

Cells multiply by fission, or by the breaking up of the cell-contents into small spores. The long, hair-like Algæ are composed of single cells attached together in line. A cell divides transversely into two, each of the two divides making four, the four divide into eight, then sixteen, thirty-two, and so on, all remaining attached. This process may be watched in the microscope, and the movements of the Protoplasm and its granules are distinctly seen in each cell.

In other species the cells divide also at right angles with the primary division, one cell dividing into four, the four into sixteen, and so on, forming a square cellular surface instead of long filaments.

When gathering specimens do not pass by any patch of more than ordinarily dark green, for it may consist of Oscillatoria, the tubular cells of which form simple, rigid, elastic, moving, oscillating filaments that never fail to interest the observer. The Protoplasm of this genus of plants is very much alive, and the motions are decided—for organisms classed as plants.

The Protoplasm of vegetable and animal cells is the same substance—adapted to the different conditions of

their cell life. All plants are composed either of single cells or colonies of cells. Thin sections of any plant or wood are shown by the microscope to be built up of countless cells. In the bark, heart, and harder parts of trees the cells originally soft and yielding, have been changed by age or exposure.

The muscle, adipose tissue, bones, cartilage, crystalline lens, nerves, brain, every part of any animal or man is composed of microscopic cells. Each cell in its growing stage is a little lump of soft Protoplasm, retains its individual life, and has its life history. The large animal represents the aggregate life force, the united "bodies and souls" of its aggregation of individual cells. The cell is to the tree or man, that which the tree is to the forest, or the man to the state. Each man is a community of specialized cells, and each cell performs its part with the energy shown when life itself is to be preserved. It prospers or fails, lives or dies with its companions.

The white blood corpuscles of man and the higher animals are protean, have the characteristic movements of amœbæ, and take within their bodies food or particles of foreign substances the same as the amœba. They have been seen to take up fine particles of indigo that had been injected into the veins, and by removing them assist in purifying the blood. When the animal of which they are a constituent part is wounded, they gather at the injured spot and eventually heal the wound with their own bodies,—growing into the new flesh.

Cells originally of the same kind, under the operations of inherited tendencies, and the varying conditions and necessities of the parent organism become nerve cells, cartilage or bone cells, muscular fiber, cells of generation, mucous membrane, brain cells, anything neces-

sary to benefit the being to which they belong. Each is to the animal what the individual crystal is to the rock, or the single vegetable cell is to the plant. The work of each one is small; perhaps not greater than that of an unicellular diatom or desmid, but in the aggregate by reason of their immense numbers, and unity of action, great results are attained. A single grain of sand counts for naught, but millions make a mountain. If the number of coral insects be great enough—the coral reefs become important islands. In the animal and vegetable economy there is nothing so important as the cell. Its relation to biology is the same as that of the crystal to mineralogy.

The ovum of any plant or animal is at first a single cell—a cell of generation. All the way along the tree of life and out upon its branches the ovum is so simple a bit of Protoplasm that it is indistinguishable in the microscope from the still form of the amœba. Throughout all, the development from the ovum is by cell division, —and the cells go on and build up along the lines of growth inherited by the cell Protoplasm, with slight variations adapting the young being to changed conditions. In its growth each cell passes through all the intermediate forms from amœboid cell to adult animal or plant;—the same course its ancestors had traversed in geological time.

Out of millions of seeds scattered every year broadcast over the ground only comparatively a few germinate, survive and mature. Out of untold millions of organisms that started up from the primæval slime, only a few favored forms survive to our times. The vast majority dwindled away and perished early. The survivors represent those best fitted to their environments. The severity of the struggle is proved by the myriads of the species

slain, and the high degree of development reached among the survivors.

It has not been a chance evolution in any sense, but the strength acquired by use, and the greater immunity from danger which is the reward of adaptation, have through the laws of heredity caused a steady, slow, but sure progress in the properties of the cells and in the grandeur and perfection of their work.

As the moral and intellectual worth of the individuals united to form a republic is the measure of the national character, so is the quality of the constituent cells the measure of the physical and mental capacity of the man. Their fidelity to their inheritance is manifested in the true breeding of the species. Their plasticity is seen in their ready conformity to changed environment. Both qualities are in evidence from monad to man.

## *CHAPTER XVI.*

## EVOLUTION OF MIND.

WHERE does mental action begin? Shall we say that all organic beings having life, power of motion, or feeling, are therefore possessed in some degree of mental powers? We have seen that all the organisms, living and extinct, have developed physically from simple cells. Have the same processes of evolution also developed the mental powers from small beginnings? The protoplasm of all vegetable cells has life, motion, soul, and is unstable, tender, sensitive to environment and free to molecular changes. The Sensitive plant shrinks at a touch. The Drosera selects and digests animal food, and a number of plants have motion.

Among the Protozoa a gradation is observable from species having only the faintest signs of motion and life, to those possessing a considerable degree of activity. The action of their sarcode or Protoplasm in the lower forms is not distinguishable either in kind or degree from that of the protoplasmic contents of the plant cells.

In the Radiolaria, Arcella, Difflugia, and other more highly developed unicellular forms that may be classed as animals, the physical and mental action of the little mass becomes more marked. The pseudopodia are farther extended and with more evident design of obtaining food. Their extensions and contractions show evidence of purpose. It builds its exquisite shell-house, feeds, moves at will, and shrinks from danger.

We cannot truthfully affirm that this simple, homogeneous lump of slime does not possess mental attributes of a primitive order. In fact, the more the infusoria are carefully studied, the more firm must the conviction become that their mental sphere enlarges and keeps in exact touch with their physical evolution. The physical and mental adaptation to circumstances proceed in the march of development within every cell, fiber and molecule, interwoven and inseparable.

The cell, when forming a separate organism, develops mentally, as we can learn with the microscope, and the same means of investigation show the same results in the higher infusoria, and the aquatic larva of insects. Such animals, consisting of a number of cells, modified and adapted to perform different functions, may be found transparent enough for easy study. In all the numerous species, as in the Tardigrada, or bear-animalcules, advance in bodily perfection is accompanied by a nearer approach to the higher animals in all voluntary motions.

The long, slim pseudopodia of the rhizopod enable it to feel external objects, and a similar extension of the cell plasma of the multicellular animal enables impressions to be felt in other parts of its body. This is the beginning of nerve fiber. A cell located in the anterior part of the body, by greater use becomes a little more sensitive than the others and becomes the starting point of a cephalic ganglion, which becomes the principal seat of mental powers. These little animals, confined in the growing slide of the microscope and watched for some time, will show considerable ingenuity and persistence in their endeavors to obtain food or to make their escape.

All authorities recognize the cephalic ganglia of insects, and the brains of the higher animals, as being the organs

of their minds. That these organs are, like the muscles, decreased in power by disuse, and increased by use, cannot be denied. Not only this, but mental action continued indefinitely in certain lines, will increase in like manner the strength and facility of mental action in those special directions, accompanied by corresponding changes of brain. Such actions becoming habitual, and being performed involuntarily, are spoken of as instinctive.

Now, among insects, from the higher animalcules up to bees and ants, there has been in their cephalic ganglia an unbroken line of evolution. Note the large and finely developed heads of the ants. They have lived by their wits and their minds and heads have become comparatively large. They construct cities, lay up stores of food in good weather, keep domestic animals, carry on long and well conducted military campaigns, and are able to talk or communicate understandingly with each other. If the reader doubts, let him study them. If ants working at constructing a chamber in their hill, make a mistake, as they often do; the supervising ant architect, on noticing the error, has been observed to require the work to be torn down and built over again. This is reason, and does not differ in kind from the workings of the human mind. All the higher insects readily change their habitual actions to make them the better conform to different conditions.

Bees hold fast with their claws and use their wings, on sultry days, as fans, to produce cooling currents of air. They modify their combs to suit the shape of hive, or tree, or any intervening obstructions. Different species of bees make different shaped cells, and ingeniously select and improve their homes to suit their various requirements. Close observation shows that there is no

lack of variety of expedients among colonies of the same species, or even among individuals of the same colonies. They recognize and like their friends, but hate and sting their enemies.

The vertebrate animals vary in nerve and brain development,—from those having no brain, only a spinal cord, without important gaps, up to the large and complex human brain. All along the line the mental keeps step along with the physical evolution, and corresponds with environments. The mental attainments like the physical qualities have gradually built up by the addition of small gains, commencing with the craving for food. Improvement kept pace with the accumulation of experiences. The enlarged necessities resulting from the increase in numbers, and the consequent more intense struggle for existence, required and caused the growth of larger and better brains.

The average weight of brain (European, male,) is 49.5 oz., female, 44 oz. Among idiots, brains are found weighing from 27 oz. down to 15 oz., and even as low as 10 oz.

As a rule men of unusual ability have large brains. Cuvier's brain weighed 64.5 oz., and Daniel Webster's 53.5 oz. The weight of the brain of the horse is given at 23 oz., of a whale 5 to 8 pounds, of an elephant from 8 to 10 pounds. The intellect of a large fleshy animal like the elephant is not in proportion to the great size of brain, for the reason that a large portion of nerve force is expended in keeping up digestion, circulation, respiration, and the action of the muscles. It often happens that smaller brains make up in quality and activity what they lack in weight.

The brain material is the same in man as in the dog, cat, or other of the higher animals, both chemically and

microscopically. In its parts and structure it is also the same, but more highly developed.

The brain is composed of nerve fibers in some parts parallel and in others interlaced with crossing fibers, a white medullary substance, a gray cortical substance, and delicate supporting tissue. The white nerve-fibers are from 1-5,000 to 1-14,000 of an inch in diameter; the gray nerve-fibers about half as large; nerve-cells between 1-300 and 1-3,000 of an inch in diameter; and the nerve-granules 1.7,000 to 1-10,000 of an inch in diameter.

The number of nerve-fibers is enormous, the optic nerve containing not less than 100,000, and the white brain matter hundreds of millions. The brain-cells are round, oval, pear-shaped and radiating, granular and nucleated, and doubtless number as high as a billion in the average human brain. They are connected with each other by nerve-fibers, and all parts of the body are connected with them by nerves, each fiber of which is isolated by protecting coats, and passes without a break, to its own part of the brain. Thus each nerve-fiber conveys its own secret message to its nerve-center in the brain. Each nerve-fiber starts from a brain-cell which is also connected with other cells and fibers. Through the cell the in-coming and out-going nerves are connected. The nerve-fibers, branching along the smaller arteries to the capillaries, are continuous with the return fibers along the veins, thus completing the circuit of the nerve currents. There is a rather close affinity between nerve force and electric force. Any disturbance at an extremity affecting one set of nerves cannot be communicated across to other nerves, but must pass up the nerve-cables to the central office, the brain, and then out to other parts. Anything that stimulates to action a nerve-fiber anywhere in the body, produces cor-

responding movements in the gray matter of the brain; coming along different isolated fibers, and to different cells, this admits of comparison of the impressions as is the case with photographs taken from slightly different directions for the stereoscope.

At this point the statement of fact will bear repetition, that this most delicate and complex organ, a city of nerves and cells, has been traced along its march of development from the primitive slime, and that in the human fœtus, the nervous system begins to form as a spinal cord; later a vesicle arises at the head, becomes a cell, a ganglion, and finally through ascending stages, that which we see it at birth,—still requiring several decades of use to reach full adult maturity.

The brain cells, built up to their present highly unstable and sensitive state, manifest their life energy in the form of consciousness and thought, when stimulated to action through external or internal causes; and by reason of the natural properties they possess, and through forces that are essentially of the same nature of, and correlated with mechanical, electrical and chemical forms of force. This action, like muscular action, exhausts, and a large supply of blood is required to replenish the waste. It is estimated that the brain uses a third of the blood supply of the whole body, and the greater the mental work the greater the amount of blood required. The changes resulting from mental activity, taking place in the substance of the brain-cells and nerve-fibers, the breaking down and building up of the plasma of the cells, requires a constant supply of new material to rebuild as in all other cells, and these metabolic changes are going on while the brain is active and must be proportional to that activity.

The sum of the physical forces used in the mental

process is the exact measure of the mental work. Force can never be destroyed, but as the physical energy in the brain disappears it manifests itself in the form of vital force in the phenomena of digestion, muscular action, thought, etc.

The time required for a sensation to pass along a nerve has been proven by experiment to be about 90 feet per second. A fraction of a second is also required for the brain to act. This fact shows its kinship with the different forms of force.

When the finger is pricked, there is of course an actual alteration of the delicate matter in the core of the nerve-fibers of that member. The impression is transmitted through the molecules in a wave of force. It reaches the brain cells and produces corresponding molecular changes there. These changes of the microscopic brain substance constitute a memory record. If the injury is repeated, the law of least resistance applies and the sensation passes along the same track.

The oftener this is repeated the more enduring will be the memory of it. Later, some similar event occurs, and the same molecular action in the brain cells is induced, which constitutes a recollection or memory of this event. The more frequently this action is repeated, —from either external or internal stimulation, the more permanent is the impression, and the more important does it seem to us. This is the case with all impressions whether subjective or objective. Nearly allied objective and subjective impressions, thus contiguous and perhaps overlapping or overlying each other in the brain substance are often mistaken—the one for the other. This fact explains much superstitious belief. Persons think they see or hear a miracle or ghost when the impression comes from a record in their own minds. It is

therefore sometimes difficult to distinguish a thought from an object.

The brain is really a double organ, and when one side of it acts an instant quicker than the other, we have no way to judge of the length of time, and from the double sensation get the idea that we have seen the same thing before,—possibly years before. This accounts for some of the superstitions. They can all be explained on natural principles.

When the brain becomes stored with an indefinite number of impressions, in different cells and centers, when one is brought up, others which are adjacent or connected with it are set in motion, or brought up, so that in determining choice of action they are necessarily compared with each other and reasoned upon.

Each train of thought is preceded by either contemporaneous or memory impressions. We have, on all subjects, definite relations mentally as well as physically, with the matter and forces of the Universe, and the relation is so close at every point that the obvious explanation is that we are integral parts of it.

The will to act, and the reasons determining the choice of action, arise from the brain action as indicated, and primarily from necessity for food and self-preservation. These are the requirements resulting from the property of motion possessed by Protoplasm. The supply of food is a requisite of continued motion, heat and life, and is the main incentive of all organic activity. Without the chemical action by which food is changed and digested there could be no will or thought. Like the Amœba, a renewal of energy gives pleasure and hope and we extend our mental pseudopodia and branch out in new enterprises; while on the other hand exhaustion brings depression and pain and we assume

the resting stage. That which we call will-power is the consciousness of the effort made to follow these conditions.

Where climatic conditions require that a supply of food be stored, as is the case with squirrels and men, memory teaches in relation to the food supply, that adequate provision must be made for future contingencies; and this requires a speculative reasoning that easily leads upward to the highest intellectual attainments. It must be remembered that in this respect considerable start must have been made in high latitudes very early in pre-historic times. There has been ample time for an exceedingly slow evolution of the higher mental qualities. Fortunately we are able to contrast savage tribes now living with civilized peoples as well as to trace intellectual development along its slow and tortuous track in historic times.

Sensation, consciousness, reason, all the mental qualities, may be considered as much properties of the matter called Protoplasm, when subjected to favorable conditions, as fluidity and crystallization in six-sided forms are of water, or heat, light, electricity, molecular motion and chemical affinity are of matter under other conditions.

We are all the better able to understand the living universal matter—because we are ourselves a part of it. In the past men have "strained at gnats and swallowed camels." They have ignored probabilities and been misled by their desires. The cry of new-born truth has been drowned in the deafening uproar of the conflict of the creeds. At last men are learning that the natural explanations are the true ones.

Man has exalted himself too much; he stands physically and mentally lineally connected with the lower

animals. He has their physical nature and mental qualities. The lowest man is intellectually on the same plane with the highest brute. Learned elephants, apes, horses, dogs, and cats are the intellectual peers of the islanders who cannot count, eat each other, are afraid of the dark, have a language of only a dozen or so sounds, and, as Alfred R. Wallace says in his *Malay Archipelago*, have a religion that consists principally of a "disgust at pork."

Men have all the qualities, good, bad, and indifferent, of all the brutes. There is little use of going through the catalogue; let each man analyze his own propensities.

Is he braver than the lion? more crafty than the cat? more cautious than the fox? more cruel than the tiger? more patient than the horse? more trusty than the dog? more timid than the gazelle? more mild than the lamb? more revengeful than the hyena? more loving than the dove? more selfish than the hog? Can he not beat any other animal at his own game? He has memory and reason; so have they. They have instinct; so has he. All belong to the same type of organisms, and are the output of the same evolutionary movement,—branches of the same ancestral tree.

The mental qualities of man and the lower animals being the same in kind, and differing only in degree, any attempt at drawing a dividing line is arbitrary and unnatural. To assert that only man has an immortal soul that will enjoy or suffer an eternal conscious individual existence, is to deny the same property to kindred animals that are unquestionably kinder, wiser and better than some men. The desire of salvation, and precedence for themselves, is so strong among some theological tinkers, that they become blind to the absurdities

of their beliefs. Each dreamer is pretty sure to always include himself, "his son John and his wife," among those elected to be saved. Some with commendable caution draw the line at the imaginary point where the ape ends and man begins. Others scarcely less cautious draw a distinction where there is no difference, and condemn to punishment or extinction all below a certain presumed intellectual grade of development. Many are doubtful of the salvation of any except those in good standing in their own peculiar church. Not a few locate the danger line in risky proximity to themselves, feeling perfectly sure only of their own prospective wings and harps. Among the hundreds of conflicting creeds, the essentials of one are often the non-essentials of others, and the onlooker is often moved to say with Ethan Allen: "Any one is welcome to my chances."

In proving the natural origin of man and the development and true nature of his mind, and his place in Nature, the work of Science would have been well repaid if it had done nothing more than to remove from mankind the fear of the punishment of hell—and the monotonous adulations of heaven.

That the dumb animals are not entirely governed by instinct, but adapt themselves faithfully to circumstances, after the reasonable manner of men, might be illustrated by volumes of well attested anecdotes. I will only mention a few for the truth of which I can myself vouch. The dog, when the house was on fire-seeing a sick member of the family brought out, went back into the house, and was seen coming out carefully carrying the family cat.

Another dog showed pleasure at the sight of a well-known neighbor who came to borrow a saddle before the

family had arisen in the morning, and went with him cheerfully to the barn. The neighbor thought it would be all right to get the saddle without disturbing the family. The dog played with him in the barn but would not let him remove the saddle, and when he attempted to leave the barn without the saddle refused to let him go and held him a prisoner until his master came. Everything was right and pleasant so long as he did not try to leave the barn.

A certain cow would seldom jump a poor fence, and never a good one, but she would let down bars nicely, readily lift the hook with her horn and open gates from the outside, and the sliding door of her stable.

An ox would let down a corner of a zigzag rail-fence in the regular manner, get into mischief himself, but always kept the other animals from going through the gap. What was right for him was wrong for them; a rather human trait.

Cats are said to think more of places than they do of people, and often return to the old home after being moved away with the family. An exception to the rule came under my observation: the old cat found homes for two of her kittens with two of the neighbors, where, possibly under her instructions, they remained faithfully. A year later she and another full grown kitten were punished for a fault, and she and the kitten left and made their home at another neighbor's. About a year later the kitten returned to the old home to stay, but the old cat never returned except as an occasional welcome visitor.

Many animals have been known to sympathize with and help and care for others that were wounded or in distress, and sometimes this has been done for those belonging to other species. I knew a dog to thus serve

an injured cat, that in its turn availed itself of an opportunity to reciprocate the kindly act.

A friend of mine had a cat that took care for some time, in a motherly way, of a flock of little orphan chicks.

But enough of this, any one who knows animals will admit that they think and reason, and they often have a consciousness of good and evil. When they do right they feel proud and happy, and they show a sense of shame and regret when they do wrong or commit an error.

Prof. Huxley stated the simple truth when he characterized the attempt to "draw a psychical distinction" between the animal world and ourselves as "futile, and that even the highest faculties and feelings of the intellect begin to germinate in lower forms of life."

Human infants and youths pass through primitive mental states progressively as did their ancestors in the evolution of the race.

If man had fallen from a higher estate he might well be ashamed of his fall. But there is consolation and hope in the established truth that he has risen from the lowest planes of life, by slow gradations and persistent efforts, up to his present high position. In place of the crude and childish theory of the fall of man, still held by some ignorant or interested theologians,—Science has given us within the memory of men yet in full mental vigor—the established doctrine of the *rise of man.*

If it were a matter of choice—which would the wise man choose to believe? It is not a matter of choice, but of fact; belief is not knowledge, and happy are we to know that the truth is teeming with hope for the future evolution of the species to which we belong.

## *CHAPTER XVII.*

## THE END OF THE PLANET.

THE future fate of the Earth and its inhabitants is a question of unsurpassed interest. Before the present Scientific Era it could not have been discussed with any considerable degree of confidence. The flood of light now thrown on the orderly evolution of worlds in the past, enables us to project the powerful search-light of the fundamental truth of the uniformity of the operations of Nature into the darkness of the future. At last we have solid foundation for judging of the future by the past. Nothing could be more absurd than the supposition that unchangeable laws of nature might produce different results in the future from those already observed. It must then be taken for granted that the Earth will continue to cool off, and become by slow degrees nearer the low temperature of the space in which it is suspended. Looking backward or forward, our mental vision beholds the steady unbroken flow of the same great stream of progress. This must continue until the planet becomes less fitted than it now is to support its inhabitants.

As the highest development yet reached by our race has been in the temperate zone, we may safely predict that progress may continue until after the temperature along the equator shall become correspondingly reduced.

Then the great centers of civilization will be transferred from the valleys of the Thames, the Hudson, the

Seine and the St. Lawrence to those of the Amazon and the Congo. The ice-cap will permanently cover the Great Lakes and the English Channel. An arctic climate will extend over Great Britain, Northern France, and the northern states of the United States and Germany, slowly but surely spreading southward, while the southern polar ice-cap shall be spreading northward.

While these changes are taking place, thousands of generations will pass away, nations will rise and fall, perhaps civilizations perish and be renewed, islands will sink and new ones rise, and the contour of continents be greatly altered. The time past since the dawn of written history is not to be mentioned in comparison. Measured in years the time will run high up in the hundreds of thousands, and perhaps reach into the millions. This must be true even when the loss of heat by the Sun is also taken into the account.

Artificial heat will become more necessary as the periods of tens of thousands of years roll by. The time will come when the wood and coal supply shall be exhausted. Electric heating, generated by solar engines, water power—from streams, waves and tides, air motors, and perhaps heat generated by chemicals, will supply the deficiency.

The food supply may possibly be maintained by improved agricultural methods and the discovery of edible chemical products, and that for an indefinite length of time. As long as knowledge is not lost the human species need not suffer from cold and hunger, for the population will not be greater than can be subsisted in comfort.

With such an outlook there can be no reason why the evolution of mankind may not continue on to higher states of development. The final freeze that Science

guarantees is far more remote and therefore less discouraging for the prospects of the world, than the old-fashioned promise of a speedy destruction by fire. The uncertainty as to the fate of the living generation is removed, with all its ever-present expectation of the imminence of the final conflagration. The declaration, "Verily I say unto you that this generation shall not pass away before all these things shall be fulfilled," does not meet the case.

Science does not invite this generation to don its robes. It permits it to rest fully assured so far as life on the Earth is concerned—for countless generations to come. The new view not only has the lesser merit of being desirable, but the greater merit of being true.

Sooner or later a practical effect of the new departure will be a general, consistent, and systematized effort to make life on this planet better worth the living; for every man, woman, child, and animal on the face of the Earth. That there is urgent need of such improvement, those belonging to the less fortunate classes can strongly testify. When true and fearless Science shall have gained full supremacy the earnings of toil will be devoted to present good, instead of being wasted on vain and fleeting ambitions and future uncertainties.

That mankind will continue to improve mentally, morally and physically, for tens of thousands of years to come, those who enter into the secrets of evolution and understand its spirit will not question. There will be rapid transit and communication, and canals for irrigation and commerce closely interwoven, all over the habitable globe.

Finally, perhaps millions of years hence; the time will come when the great problem of the final extinction of the human species will have to be considered. All

the appliances of science and art will not avail to supply sufficient warmth and food. Mathematical calculations may then determine the generation with which human life on the planet must cease. Forewarned and forearmed, there will then be no children of men to freeze and starve. Wise counsels will prevail, and the race, like an aged philosopher, will retire from life without a struggle and without regret, with conscious rectitude and moral courage—bowing cheerfully to the inevitable.

Another picture might be drawn of the last men, steeped in superstition and selfishness, and swayed with passion, struggling against fate, praying in vain to their equally helpless gods, crowded, starving, freezing, digging deep in the ground for warmth, eating the last animals, seeking shelter and protection, and finally the last men like the first, with nails turned to claws by digging, covered with hair, with teeth and jaws projecting, wild-eyed, devouring each other, and ending their days in a frenzy of despair.

The evolutionist has every reason to believe that scientific and ethical culture will sustain the intellectual and moral strength of the dwindling inhabitants of the dying world, as at last life shall be voluntarily relinquished.

We have caught a glimpse of the unnumbered millions of years that dragged their weary length along before the Earth became fitted for habitation, and of the vast period of time that it has sustained life, and now we are ready to imagine the equally incomprehensible period that must needs elapse before the desolate and declining globe shall have ceased to exist as a planet. We have traced its birth, youth, maturity, and are now invited to follow its old age, death and disintegration.

Fortunately, we do not have to depend entirely on reason, or draw unwarrantably on imagination, for we have the Moon as an illustration of an advanced stage through which a cooling planetary body must pass. It teaches that the time will surely come when the Earth will become old and wrinkled; its waters absorbed in the cold and cracked crust; its atmosphere solidified or absorbed; its surface rent by the sudden liberation of pent-up gases; its day equal to its year; the rocks crumbling under the strain of great changes in temperature; its craters circular because there will be no wind to blow the volcanic dust,—a broad expanse of desert without a breathing thing or a green leaf upon its frozen surface.

After this stage shall have been reached, many millions of years must yet elapse before the central regions lose all their heat, and the globe becomes throughout as cold as the regions of space. The Moon, long since dead and decomposed, may be again united with its Mother Earth, both in their turn to drift to, or around, the cooling and dying Sun in the form of meteoric dust. The bodily tides caused by the attraction of the Sun and the larger planets will help to break up the cold and brittle mass.

It is a matter of common knowledge that when metallic substances lose their heat, they become brittle and are more easily broken to pieces. It is the energy developed by molecular motion that causes the particles to adhere in a mass. As the molecular activity stops, force in all its protean forms ceases to be manifested.

The process of disintegration would probably be aided by the conditions arising from the change of the Earth's orbit to a more elliptical form, until it finally becomes like the orbit of a comet or meteoric swarm; the Sun aiding the dispersion.

It is fair to assume that the most attenuated forms of matter in interstellar space differ from other matter only in their vastly greater atomic distances. In the presence of active bodies like the Sun, these thinner gases would assist the chemical action and be condensed. This would cause a rapid inflow of them,—toward the point of least resistance, and for indefinite distances. All bodies, freely suspended in a state of equilibrium, whether large or small would be drawn the same way, and move with the current of atoms. This would also be a steady supply to feed the energy of the Sun. It would help to explain the causes of the attraction of gravitation, and support the theory that gravitation equals the difference in excitability of two bodies. It would also act as the medium for the transmission of light, heat, electricity and other radiating vibrations of solar energy. The supply of the attenuated medium would be kept up by the decomposition and consequent separation of the atoms of the dead worlds.

When all the components of the solar system become entirely cooled off, and their molecules lose their attraction of cohesion, active bodies in remote space, attracting, however distant and feebly, will cause the molecules and small bodies to drift farther apart. Any remaining motion of rotation would throw off non-adhering dust.

All internal motion of atoms and molecules having ceased, cohesion and gravitation end, and the particles fall asunder. When condensation ends, disintegration begins. Matter, ultimately separated, with all its force at rest, falls apart into nebulosities, such as have been previously described.

If gravitation is proportional to excitation, it would be at its highest at the culmination of the sun-period,

and lowest at the period of greatest atomic separation. Our knowledge of nebulosities, comets, meteorites, and the most attenuated forms of matter generally, is corroborative of this opinion. The attenuation, lack of points of condensation, and irregular outlines and shapes of the nebulosities, point strongly to a lack of gravitation, and this at the very point in the cycle of evolution and disintegration, where such a condition would be expected to obtain.

This brief and imperfect story of the *life history of a world*—began in a telescopic nebulosity, ran a period of say a billion of years and ends in a nebulosity—a complete circle.

It is only one revolution in Nature's eternal rounds. The steady march from nebulosity to nebula, from nebula to sun, from sun to planet, from planet to protoplasm, from protoplasm to man, from man to the culmination, from the culmination to the decline, from the decline to meteoric dust, from dust and atoms to nebulosity,—reaches a moment's rest, nay,—the movement continues without interruption—along the endless pathway of change.

In all the immeasurable changes of matter that have taken place in the 1,000,000,000 years, not an atom has been gained or lost, not a particle of its force has been augmented or diminished, and it continues its eternal journey with every potency intact.

Any day of the billion years an observer looking out upon the Universe, from any known star, would have seen worlds and systems in all stages of growth,—from birth and youth to old age and decay. It is in truth a "Wilderness of Worlds." The dust of the old is the substance and nourishment of the new. Any one day in the past, or in the future, is, and will be as much a day

THE BASELESS FABRIC OF A VISION.

And, like the baseless fabric of this vision,
The cloud-capp'd towers, the gorgeous palaces,
The solemn temples, the great globe itself,
Yea, all which it inherit, shall dissolve;
And, like this unsubstantial pageant faded
Leave not a rack behind: we are such stuff
As dreams are made of, and our little life
Is rounded with a sleep.—*The Tempest*,
(Knight's Shakespeare, Act IV., Scene I.)

of beginning, or of creation,—as any other. In one sense every day is a day of creation.

Those who assume the existence of an intelligent power or creative force, back of, or outside of matter, have very little real insight into the working of Nature. They take the form for the substance. They measure Nature with a human micrometer as the standard. To them words and catalogues are greater than works and a thorough understanding of principles and substance. There is no evidence of the characteristic caprice of intelligence in the always uniform order of Nature. The Universe was not created, but always existed.

All things go through their natural changes and are the manifestations of the properties of the Universe, and contain in and of themselves, and ever have, and ever will, all there is of eternal energy. The infinite and eternal energy, in all its protean forms, is ever at one with matter, whether optically visible or not, and the energy is no more a product of matter than matter is of it; but simply a property of matter from which it cannot be separated. In this idea we have the true Monistic conception of the Universe. The material Universe is all there is of it, but in the broad sense—it is potent and living material.

responsibilities of freedom discipline the judgment and lead to wise conclusions. Boys never learn to swim until they gain access to the water. Liberty is the father of strong men. Free, brave and honest men will seek the truth for its own sake, and if without bias, sufficiently intelligent, and broad minded, will eschew all forms of supernaturalism. Study Science, in books and Nature, all your spare time, including Sundays, and the truth will make you free. Try it.

Those whose interests require that the people should be lulled to sleep, are forever preaching contentment. They deprecate unrest, well knowing that doubt, and dissatisfaction with things as they are,—are the mainsprings of progress. Contentment would have retained the stage coach, as it has a still more worm-eaten theology. Instead of dependence upon others, and upon a dead and decaying past,—a living, active self-reliance is the one thing needful.

There is yet great and imminent danger that the higher civilization that Science has enabled us to enter upon, may be overthrown and lost to humanity for centuries to come, as was the case with the knowledge once centered at Alexandria. It has been well said that—"Eternal vigilance is the price of liberty." This is *doubly* true of religious liberty,—the slowest growth of all. It will never do to forget the cost of the moiety we enjoy. It is our duty to so do our part that our posterity may be saved from persecutions such as our ancestors passed through. The upward march of mankind, shackled with the chains of superstition, has left all along its trail—foot-prints stained with blood. The monuments of progress have been broken instruments of torture and the extinguished fires of fanaticism.

Science is sincere and tolerant. It has never perse-

cuted. Its hands are unstained. Let them always remain so. It has suffered wrong in silence. To escape persecution and conflict it has with Galileo often denied the truth. To escape ostracism, and the numerous intolerant aggressions of the Church it too often suppresses, and even denies the truth to-day. The common remark among confidential friends that—"we know these things to be true, but it is best to keep still; it will not do to come out openly and let it be known," is the expression of a rule of conduct, among a large and intelligent class. Reason is less aggressive than unguided emotion.

Religion is emotion without true knowledge of Nature, and where it begins Science ends. There is a higher emotion,—a higher poetry of Science, that is safe, tolerant, progressive and enduring. When this is reached general efforts will be put forth, without fear or favor, to redeem mankind from the intemperance of selfishness and superstition.

To unlearn the teaching of centuries, emphasized with the rack and torch, is a slow process. Bruno was burned *after* the discovery of America and the circumnavigation of the globe. We can remember when Tyndall incurred the displeasure of the Church by his Belfast Address, and a bishop, at Buffalo, warned his flock against Huxley, when he was an honored visitor at the meeting of the American Association for the Advancement of Science. Tyndall and Huxley were not the ones who were harmed; and a monument to Bruno stands on the spot where he suffered martyrdom.

The time is rapidly approaching when the opponents of supernaturalism will show an unwavering and unbroken front. In this age of rising Science, so-called orthodox religion owes the world an apology for its existence. It should abate its arrogance and presumption,

see itself as others see it, repent its past crimes and present sins, and voluntarily come down out of the saddle.

Its heaven has vanished into thin air. Its hell has disappeared with the foundations of the earth—and will eventually freeze up with the planet. Its prayers and pretended miracles have never interrupted the course of the law of cause and effect. Its persecutions are recoiling upon itself. Its every position taken in opposition to Science has been to it a boomerang. It has weakened morality by the insecurity of the foundations it offered. It is being forced to revise its theory of charities to accord with the teaching of Science. Its chronology and cosmogony are overthrown. The rib-story, and the fall of man, have vanished with the deluge and the dispersion of languages at Babel. Its emotional "experiences" are explained on physiological grounds. Its eternal life will hardly survive the death of the planet. Its ritual, baptism, trinity, symbols, immaculate conception, relics, etc., were no less significant to the Pagans than to it. Its kind of creative work has taken a rest. Its belief is not knowledge, nor works; and faith is credulity without proof. Its deity is an invisible and imaginary being, man made, modeled after a dead patriarch, chief or king, is the mysterious source of the "right" of kings to rule, and is waning with them. Science killed the devil. Science investigates, and the people think. Old creeds must follow the flint flakes. People are counting the cost and will demand the best.

It sums up that the whole theological structure is an artificial fabric, built on sand, in the infancy of the race, and to-day is a crumbling ruin. Intelligent theologians are thinking of what can be saved from the tumbling pile. The ruins of ancient temples still show, cut in stone, the images of the gods they symbolized. In time,

not may-be's,—to new facts, not old dreams. The bulk of the early speculations, reasoning from inadequate data, were much the same as the old idea that a portion of the intellect of men was located in the viscera. Doubtless a more frugal and temperate diet, and opportune doses of hepatic remedies, would have saved the world the inflictions arising from many dreaming stomachs and prophetic livers, like those of Daniel and John the Revelator.

Science has forever disposed of the idea that the Universe revolves around the Earth and the whole around the few elect. Is not eternal rest for the ego, and eternal utility for the material substance and its changing forces, better to believe than the doctrine of eternal happiness for the few and endless misery for the many? Better all cease from consciousness, become as they were before being born, than that even one should suffer the pangs of eternal torment. After all it is a question of facts,—not wishes.

We go to Nature for facts,—not to a self-contradicting revelation that does not reveal. A really divine revelation could as easily as not have been set up, stereotyped, and run off with a perfecting press, in all the languages and dialects, and left free of uncertainty, doubt or mistake; instead of the precious message being picked up by chance hearers, in a fragmentary way, passed from mouth to mouth, becoming mere hearsay, and finally reduced to writing a century or so after the events, when it had become a vague and somewhat inconsistent and questionable collection of traditions. However, in that case, the occupations of the expounders would have been gone, and their pay also.

There are few of us who have not inherited a prejudice in favor of the religion of our ancestors. Many of us had early training and environments, calculated to lean

us still further from the perpendicular in the same direction,—leaning toward error. A few are educated and accomplished, but get so little real insight into the nature of things as to never be able to discover that all their branches, vigorous as they may be, grow from a leaning trunk. Born and educated in a rut, the greater the education in the same direction the deeper the rut becomes, and the less hope there is of getting out of it. Such men are not to be condemned hastily, for they are not hypocrites, but honest and mistaken. Oh, that the rising generation might grow up straight. Like the even branches of a perfect tree, growing in the open, our youth should reach out for light equally in every direction. The powers of the darkness of superstition would then be without hope.

Organized church power is exercised to intimidate the timid or dependent, business men and politicians, to corrupt the text-books, to secure controlling influence on Boards of Education, to introduce religious instruction in secular schools supported by general taxation, to put a recognition of a religion in the Constitution of our free country, and bias and control the plastic and expanding minds of the young and inexperienced. Hard and persistent work is done to make error seem respectable and truth disreputable. But the Earth does move whether they deny it or not,—and they themselves evolve.

In these days, as in the days of Galileo, the steady march of scientific discovery goes on, the church denies, persecutes, sneers, falls behind, and finally has to start a fresh trot, limping along in the dust in a vain effort to catch up,—in the meantime shouting hysterically to the multitude, to make it appear that it has all the while been in the lead. Then come fine spun theories, and a new explanation of an old revelation, to try to reconcile

dogma with fact. But a round peg never fits a square hole. To hide the failure, the devil fish is imitated and a cloud of ink is thrown out to blind the searchers.

It is too often true in every walk in life that the internal man is sacrificed to external fortunes. Would that men would more generally heed the great saying of Socrates :—"May I esteem the wise man rich, and may I possess only such measure of gold as a wise man can at once bear and use."

The world needs more unbiassed, broad-minded thinkers, who build upon the solid foundations of extensive personal knowledge of the operations of Nature, —and are ever enthused with love of the truth. To such minds ethical principles founded on experience and Nature's teaching, and not upon a misty supernaturalism, become a living reality and possess an enduring basis. Scientific study leads the fearless pioneer to the richest ethical and intellectual fields, where he can build his home on the sure foundations of enduring truth. He fears no consequences, but accepts the truth because it is right. Facts become to such men immeasurably more important than popular beliefs, and fear ceases to intimidate, haunt, warp and disturb.

As the forces of Nature take the place of the gods in all the operations of the cosmos, so in the political world the collective will of the people displaces the kings. A government by natural laws leaves no room for divine interference, as a government by the people tolerates no kings. Kings claim to rule by divine right,—and must disappear with their divinities. To be really free the people must rid themselves of both gods and kings. The fear of either—enslaves, and needlessly and harmfully taxes brain and hand.

There is an irrepressible conflict between Science and

religion. They are as incompatible as oil
Those among us who know the truth have a
form for ourselves, our generation, and fo
are to follow. We owe fidelity to the truth.
be our endeavor and pride to assist in c
times from the charge that this is the age o

Our zeal should be tempered with justice
ance. The history of the Church is a chapte
The minister spends his time relieving som
making others. There is no danger of our
their ways. The methods of Science, Reaso
thought are as much superior to theirs a
printing press is to a notched stick; and fo
reason,—it marks a higher plane of evolutio

One of the most encouraging signs of the
evidence of the disintegration of the Churc
crumbling block it has passed the culminat
its life, and like everything else that is amer
general laws of evolution it is falling asunder,-
reds of sects, each in its turn tending toward su
This familiar evidence of decay cannot escap

The orthodox of to-day would have been
as heretics half a century ago. Those mos
will be content if they can rescue from
wreck of Theology, the shadowy idea of an
creative force; a tacit belief in the immort
soul; and the continuance under any pre
organizations that bring to them power and

When man comes to know himself as he
by Science, will he continue to war upon his
gun and greed? Will the few continue to ho
in fear and under tribute? We trust not. T
of true knowledge, and the mental and m
and development that go with it, is to le
*toward altruistic* principles. Self-reliance

stricted opportunities, and the trained spirit of truth and justice will finally banish the necessity for alms-giving and alms-taking, with their admittedly evil effects. There will be true freedom when each person may be entirely independent in living and in thought, and still unselfish, and mindful of the general good.

Imagine the absurdity of a few aggregated atoms, mostly hydrogen and carbon, inclosed in a human skin of the same material, warring fiercely with another skin-full of chemicals over an evanescent inconsequential crumb. Such are the results of the selfishness and ambitions of men. This had been justifiable in the early stages of evolution when the struggle was one for bare subsistence. It can never be justified where it is done to gratify greed and glory.

Imagine an ant, so far forgetting the customs of its fraternal community, as to hoard up for itself a store of dead insects, or establish a monopoly in aphides. How ridiculous it would appear to unprejudiced observers, when putting on style, clambering upon, and generally assuming superiority over its less greedy and therefore less prosperous brethren. There can be very little or no difference in principle between the same class of actions, whether performed by ants, swine or men.

Science whispers in our ears a broad lesson of our own littleness, and our duties to ourselves, our kind, and to all animated organisms. Our lives should be shaped along the lines of our best capabilities. For the good of the future of the nations and the race—the old hoarding instinct should be confined within the limits of reasonable needs. Lavish expenditure also has its dangers. The squirrel commendably makes provision for the winter supply; but his starving enemies would be numerous if he so far forgot equal rights as to hoard *without limit*. Empty stomachs have no consciences.

There is always a yearning for free thought, free speech, and free action. Repression in any form, however polite and velvety, can not always succeed. Bottle up chemicals or men and sooner or later they will burst their bonds. The tighter they are sealed the greater the danger. The reaction is inevitable, and its result sure. As well attempt to permanently repress any other awakening energy of the Universe.

It cannot be prevented,—it may be delayed for the time; but the march of the army of Science is onward and upward. As sure as the worlds revolve—the time will come when men shall be no longer bound to a dead past. Regenerated and disenthralled, life's swift passage will be a pleasant and happy journey, through useful, ornate and peaceful paths, with overflowing love and fraternal kindness on every side.

The only solid foundation for a roseate faith in the future lies in the truth of evolutionary Science. When the gain of the past is known to be founded on true, eternal, and unchangeable natural principles, predictions of future progress assume mathematical certainty.

Although mental action may be considered as automatic, yet there is a natural power of internal selection which may be exercised along the lines of external natural selection and lead to more rapid evolution. The struggle to become better, wiser and happier is fully justified.

The insanity of greed and supernaturalism is sure to give way, sooner or later, before the triumphant march of scientific sanity. The sun-light of truth and freedom shall surely dissipate the fogs of error and fear;—and equality, fraternity, hope and love, radiating happiness to a long suffering world—shall stand secure upon a pedestal as broad and enduring as the Universe.

## ACKNOWLEDGMENTS.

IN the broadest sense, a book is a product of evolution; and in a more restricted sense it is still a growth. There are no exceptions.

Many books have contributed, directly, or indirectly, more or less, to the facts and ideas set forth in the foregoing pages. In the way of acknowledgment, and to assist the student who wishes to become better acquainted with the facts relating to the human species and other branches of science, some of the authors are here specially mentioned.

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Above, and including all others, is the book that contains all there is that is true,—*The Book of Nature:* the pages, of which everywhere present, are invitingly open to all mankind. Each person knows something of Nature, and in a scientific way, and clearer comprehension is within reach of every earnest and honest investigator.

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impartial, and so reasonable, t
text, even "The wayfaring n
fool, need not err therein." I

"I have in my mind a wildernes
gigantic size; in the distance they
gradually until the utmost limit of
clearing is to be seen. The ground
which are beginning to vegetate.
and young trees, and mature trees;
the dead, and the prostrate, moul
but natural scene.

"I raise my eyes and look outwa
of worlds. The one on which I sta
innumerable multitude beyond fad
telescope; my vision is extended
come into view, and in the thous
vision fade gradually until in the o
caught of faint points of light. The
the trees, and the great deep of spa
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"How grand, complete and subl
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